DOCUMENT RESUME

ED 233 175 CE 036 655

TITLE	Welding.
INSTITUTION	South Carolina State Dept. of Education, Columbia. Office of Vocational Education.
PUB DATE	83
NOTE	203p.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC09 Plus Postage.
DESCRIPTORS	Behavioral Objectives; Course Descriptions; Guidelines; *Job Skills; Lesson Plans; *Metal Working; Safety; School Safety; Secondary Education; State Curriculum Guides; *Trade and Industrial Education; *Welding
IDENTIFIERS	South Carolina

ABSTRACT

This curriculum guide is designed for use by South Carolina vocational education teachers as a continuing set of lesson plans for a two-year course on welding. Covered in the individual sections of the guide are the following topics: an orientation to welding, oxyacetylene welding, advanced oxyacetylene welding, shielded metal arc welding, TIG welding, and MIG welding. Each section contains a series of lesson plans that includes a suggested instructional time, behavioral or performance standards, criteria denoting a measure by which the student and instructor know when the objectives have been successfully completed, related references or resources, instructor directions for presenting the information, student activities to reinforce instruction, and review points for the student. A bibliography containing resources to supplement each unit and a list of needed equipment conclude the guide. (MN)

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WELDING

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Produced by
SC Department of Education
Office of Vocational Education
Vocational Curriculum Development Section
Columbia, SC 29201
1983

CE036655

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ACKNOWLEDGMENT

Recognition and grateful appreciation are extended to the Welding Curriculum Committee members for their valuable contributions. This guide is a revision of the 1972 Curriculum Guide prepared by the Fairfield County Public School System, in Winnsboro, South Carolina.

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INTRODUCTION

Welding instructors in South Carolina have had a slight advantage over instructors in some of the other vocational areas in that a curriculum guide was developed over ten years ago which stated behavioral objectives and learning activities. As a result, the 1972 guide needed only minor revisions to bring it in line with the latest technology and procedures for today's welding class.

These behavioral objectives were written before it was the popular choice of format. They are based on job entry skill levels which are required by business and industry. Each objective is stated in performance terms so that the instructor, at any point in the unit, is able to measure the student's progress toward obtaining that objective. The objectives are formulated in such a way that the student is able to work individually at his/her own pace toward meeting the objectives. Although time limits are given for each unit, the instructor should be aware that all students progress at different rates and that the suggested time is just an estimate for average students.

The format of the **Welding Curriculum Guide** was developed to allow the beginning instructor to follow it explicitly if in doubt about the sequence of activities or to allow the seasoned instructor to have the flexibility to add or delete where appropriate for the class needs. In either case, the instructor should review the entire Guide prior to beginning class. In this way, the instructor is prepared for the year's work with lesson plans, needed equipment, materials, and composite safety instruction.

The instructor must also be thoroughly familiar with the safety measures required for the teaching of welding. Although this Guide provides some instruction on safety, the instructor must integrate safety requirements into each unit.

HOW TO USE THE GUIDE

The **Welding Curriculum Guide** may be used as a continuing set of lesson plans for the two-year course or it may be divided into a first-year, second-year, and third-year curriculum. Since welding classes across the state differ in two-hour and three-hour blocks of instruction per day, the lesson plans have a suggested instructional time in hours in order for the instructor to determine how the class should progress. For example, the lesson plan will suggest three class periods which would mean three hours of instructional time.

The guide is divided into five basic instructional areas with the main portion being the Welding Course Outline. The outline includes orientation, oxyacetylene, shielded metal arc, TIG, and MIG. The lesson plans on these topics may be divided according to levels of instruction as shown on the chart on page 4.

Lesson plans have been developed to assist the instructor in presenting the information. Each lesson plan consists of the following parts:

1. Lesson plan title
2. Suggested instructional time
3. Behavioral or performance objective
4. Criteria denoting a measure by which the student and instructor know when the objective has been successfully completed
5. Related references or resources
6. Instructor directions for presenting the information
7. Student activities to reinforce instruction
8. Review Points for the student

The Guide is arranged so that each lesson plan has suggested resources which are on the State-Adopted Textbook List. A bibliography containing resources to supplement each unit makes up the last section of the Guide.

Following the instruction and demonstration, the student will perform jobs which use the skills and information presented in the demonstration. As the student develops these skills, he/she may progress from one type of joint to another and from the flat position to more difficult positions such as vertical and overhead position welding. While some students are working in oxyacetylene welding, others may be working with the arc welding processes. It would not be uncommon to have students working in oxyacetylene welding, oxyacetylene cutting, arc welding, TIG welding, and MIG welding concurrently.

As the student begins to master one type of welding, he/she may rotate into another area of welding. The instructor can determine when a student is ready to progress to the next type of welding by applying the criteria indicated in each of the units. One basic criterion for each unit is to have the student perform the job indicated in that unit with a high degree of accuracy.

Undoubtedly there will be students who cannot finish the prescribed objectives during the required course time. As soon as these slower students are identified, the instructor may want to have these particular students on one type of welding so that employment as a welding operator in industry would be possible.

Evaluation items (Review Points) are given at the end of each lesson within each unit and can be combined with other evaluation items to provide a six-weeks test, nine-weeks test, mid-term and/or final examination. At any point during the program, the instructor should be able to give an exact appraisal of each student and his/her level of performance within the program. Should a student drop out of school during the year, the instructor should be able to inform a prospective employer as to the level of performance of that student at the time he/she dropped out of the program. The instructor should keep accurate records of each student's progress on a chart similar to those provided by the State Department of Education.

The **Welding Curriculum Guide** is relevant to and reflective of the world of work in welding. This Guide functions as a teaching tool for assisting the instructor in organizing the sequence of concepts and tasks into a simple format. If the course outline and lesson plans are followed, the course will flow smoothly and sequentially, and, as a result, the student will be prepared to perform efficiently and effectively on the job.

SUGGESTED OUTLINE FOR WELDING

TWO-HOUR BLOCK: 1050 total hours

FIRST YEAR	SECOND YEAR	THIRD YEAR
I. Orientation and Safety II. Oxyacetylene (Plate) III. Shielded Metal Arc (Plate)	I. Orientation and Safety II. Advanced Oxyacetylene (Pipe) III. Advanced SMAW (Pipe) IV. TIG V. MIG	I. Orientation and Safety II. Advanced Oxyacetylene III. Advanced SMAW IV. TIG (con't) V. MIG (con't)
Earn two units/360 hours total.	Earn two units/360 hours total.	Earn two units/360 hours total.

THREE-HOUR BLOCK: 1050 total hours

FIRST YEAR	SECOND YEAR
I. Orientation and Safety II. Oxyacetylene III. Shielded Metal Arc	I. Orientation and Safety II. Advanced Oxyacetylene III. Advanced Shielded Metal Arc IV. TIG V. MIG
Earn three units/540 hours total.	Earn three units/540 hours total.

ORIENTATION

Orientation
Lesson Plan 1

Suggested instructional time
9 class periods

SAFETY

OBJECTIVE

Given a teacher-made test on general safety rules in a welding shop, the student will be able to demonstrate a basic knowledge of safety by scoring 90% or above on the post test.

CRITERION - REFERENCE MEASURE

The student will list and explain the rules for personal and shop safety. The student will conduct a shop safety inspection tour.

REFERENCES

Welding Technology, Chapter 6
General Industry Safety and Health Regulations, Part 1910, pp. 23737-23750
Welding: Principles and Practices, Chapter 15
"General Shop Safety," Library Filmstrip Center (film and cassette)
"Superwelder," South Carolina Department of Education (film)

INTRODUCTORY STATEMENT

Safety is an important factor in welding skills. Each student must be given proper instructions both in the use of the equipment and in correct safety procedures. This must be accomplished before the student is allowed to operate the equipment alone. The student must assume the responsibility for following the safe practices.

Presentation Outline	Activities
I. General Shop Safety II. Personal Safety III. Fire Prevention IV. Safety Inspection Tour	1. Distribute and discuss the rules for general shop safety, personal safety, and fire prevention. 2. Conduct a safety inspection tour with the students.

REVIEW POINTS

1. Present and be able to explain rules for shop safety.
2. Present and be able to explain rules for personal safety.

GENERAL SHOP SAFETY

1. While handling or using any welding equipment, comply at all times with the safe practices prescribed by the instructor.
2. Keep all equipment in clean and safe operating condition, free from oil and grease and liquid and metallic particles that can cause short circuits.
3. Always use equipment a safe distance from flammable and explosive materials and gas cylinders.
4. Always use equipment in well-ventilated areas.
5. Never work in damp areas without suitable insulation against shock.
6. Always keep a safe, clean working area.
7. Never weld or cut directly on a concrete floor.
8. Do not mix horseplay and welding.
9. If welding or cutting is done on a wood floor, sweep the area clean and wet it down or cover it with steel sheets, asbestos, or sand.
10. If work can be moved, take it to an area where fires can not start.
11. Keep fire extinguishers handy at all times.
12. Never cut or weld on containers that have held inflammables until they are completely purged and are safe from explosions.

PERSONAL SAFETY

1. Always wear the proper goggles or shields when welding or observing welding.
2. Wear gauntlet-style gloves of heat-resistant leather or asbestos to protect hands and wrists. Always keep the gloves free from oil and grease.
3. Make sure that clothing is free from oil and grease.
4. When doing heavy cutting, wear fire-resistant apron, sleeves, and leggins.
5. Keep sleeves rolled down, loose pockets closed, and cuffs or trousers turned down to avoid catching hot sparks or slag.
6. Wear boots, not low-cut oxfords which can catch hot sparks or slag.
7. Weld where ventilation is very good. If ventilation is poor, wear a respirator.
8. Do not allow your clothing to become saturated with oxygen or air that is rich in oxygen.

FIRE PREVENTION

1. If welding or cutting is done on a wood floor, sweep the area clean and wet it down or cover with steel sheets, asbestos, or sand.

2. Protect wood or combustible materials from direct heat. Don't forget to check area directly above work.

3. When cutting iron or steel, prepare the place where it will drop. Sand may keep a wood floor from igniting. Be sure no fellow workers are below.

4. If work can be moved, take it to an area where no fires can start.

5. If work can't be moved, see that nearby combustibles are protected by sheet-metal guard, asbestos curtains, etc. Make sure sparks can't fall into or roll under combustibles.

6. Have somebody stand by to watch where sparks fall. Goggles prevent the cutting operator from seeing where many of the sparks may land.

7. Keep fire extinguishers handy at all times. Pails of water or sand can prevent many fires from starting.

8. Never open an acetylene cylinder valve near open flames, other welding and cutting, etc.

9. Shut off oxygen and acetylene at the cylinder valves if you leave the area. Don't leave pressure in hoses.

10. Never cut or weld on containers that have held inflammables until the instructor has pronounced them completely purged and safe from explosions.

Orientation
Lesson Plan 2

Suggested instructional time
6 class periods

WELDING INDUSTRY

OBJECTIVE

Given a teacher-made test on welding conditions and processes, the student will be able to demonstrate a basic knowledge of the welding industry by scoring 80% or above on a post test.

CRITERION - REFERENCE MEASURE

The student will: (1) list companies employing weldors in local and adjourning areas; (2) list characteristics which describe the typical working conditions for weldors; (3) list the chronological development of oxyacetylene welding and arc welding; and (4) list the major welding processes.

REFERENCES

Welding: Principles and Practices, Chapter 2
"Career in Welding," Library Filmstrip Center, (film and cassette)
Consider a Career in Welding (pamphlet)

INTRODUCTORY STATEMENT

There is widespread use of welding in industry; a situation which provides a constant source of employment for weldors. Industries using welding range from building aircraft to making household appliances.

Presentation Outline	Activities
I. Development of Welding Industry II. Jobs Available in Welding III. Major Welding Processes	1. Distribute and discuss information about the welding industry and about companies in the community that employ weldors. 2. Discuss the characteristics of typical working conditions of weldors.

REVIEW POINTS

1. List the characteristics which describe the typical working conditions for weldors.
2. List the companies in your area which employ weldors.
3. Describe the development of oxyacetylene welding and arc welding.
4. List the major welding processes.

I. **Development of the Welding Industry**
   A. Oxyacetylene process
   B. Metal arc welding process
   C. TIG welding process
   D. MIG welding process

II. **Jobs Available in Welding**
   A. Welding operator
   B. Weldor
   C. Weldor fitter
   D. Specialist weldor
   E. Welding technician
   F. Welding supervisor
   G. Inspector
   H. Welding engineer
   I. Welding instructor

III. **Major Processes**
   A. Oxyacetylene welding
   B. Metal arc welding
   C. Inert gas welding
   D. Resistance welding
   E. Automatic welding

Orientation
Lesson Plan 3

Suggested instructional time
6 class periods

BLUEPRINT READING

OBJECTIVE

Given a teacher-made test on blueprint reading, the student will be able to demonstrate a basic knowledge of blueprint reading by scoring 80% or more on a post test.

CRITERION - REFERENCE MEASURE

The student will: (1) write the purpose of a blueprint and the three basic elements of a blueprint; (2) identify and name the functions of the common lines and the basic types of dimensions used on blueprints; and (3) make a simple blueprint drawing according to the instructor's specifications.

REFERENCES

Welding: Principles and Practices, Chapter 13

INTRODUCTORY STATEMENT

In this lesson, no attempt is made to teach blueprint reading in detail. The basic fundamentals are included so the student may be able to use blueprints in the welding shop.

Presentation Outline

I. Purpose of the Blueprint
   A. Convey a message using signs, symbols, and line
   B. Give a mechanical picture of the object
II. Basic Elements of a Blueprint
   A. Lines--shape and dimensions
   B. Dimensions--size and location
   C. Notes
III. Views--Front, Top and Side

Activities

1. Discuss the purpose and the basic elements of a blueprint.
2. Identify and discuss the functions of the common lines used on blueprint.
3. Assign students to make a simple blueprint.

REVIEW POINTS

1. What is the purpose of a blueprint?
2. What are the three basic elements of a blueprint?
3. Make a simple blueprint drawing according to the instructor's specifications.

Orientation
Lesson Plan 4

Suggested instructional time
6 class periods

WELDING SYMBOLS

OBJECTIVE

Given a teacher-made test on identifying welding symbols and the parts, the student will be able to demonstrate a basic knowledge of welding symbols by scoring 80% or above on a post test.

CRITERION - REFERENCE MEASURE

The student will identify the common welding symbols found on blueprints. The student will identify and write the significance of the parts of a welding symbol.

REFERENCES

Modern Welding, Chapter 28
Welding Technology, Chapter 26
Welding: Principles and Practices, Chapter 14
Symbols for Welding

INTRODUCTORY STATEMENT

A skilled weldor must not only be competent in the manipulation skills of the trade, but also in interpreting trade drawings which describe the work that must be done. In order to do this, the weldor must be familiar with the common welding symbols.

Presentation Outline

I. Common Welding Symbols
   A. Square groove
   B. Vee groove
   C. Bevel groove
   D. U-groove
   E. J-groove
   F. Fillet
   G. Plug or slot
   H. Metal-thru
   I. Back
   J. Surfacing
II. Parts of the Welding Symbols
   A. Reference line
   B. Arrow

Activities

1. Describe and discuss the common welding symbols used on blueprints.
2. Identify and explain the parts of a welding symbol.
3. Draw a simple blueprint with welding symbols.

REVIEW POINTS

1. List the common welding symbols and their parts.
2. What is the purpose of the parts of the symbol?
3. What is the symbol for the different types of welds?

Orientation
Lesson Plan 5

Suggested instructional time
6 class periods

METAL PROPERTIES AND IDENTIFICATION

OBJECTIVE

Given a teacher-developed test on metals, the student will be able to demonstrate a basic knowledge of metals and their identification by scoring 80% or above on a post test.

CRITERION - REFERENCE MEASURE

The student will identify ferrous and non-ferrous metals.

REFERENCES

Modern Welding, Chapter 24
Welding Technology, Chapter 2
Welding: Principles and Practices, Chapter 3
"Basic Metallurgy," Parts 1 and 2, Library Filmstrip Center (film and cassette)

INTRODUCTORY STATEMENT

Presentation Outline	Activities
Major Fields--Ferrous and Non-ferrous I. Types of Irons and Steel II. Methods of Identifying Iron and Steel III. Manufacture of Iron and Steel	1. Describe and discuss the difference between ferrous and non-ferrous metals. 2. Provide samples for identification. 3. Explain the methods of identifying iron and steel. 4. Discuss the types and manufacture of iron an steel.

REVIEW POINTS

1. List ferrous and nonferrous metals.
2. Describe types of irons and steels.
3. Describe the manufacture of iron and steel.

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OXYACETYLENE

Oxyacetylene
Lesson Plan 1

Suggested instructional time
6 class periods

SETTING UP EQUIPMENT

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to demonstrate the proper procedure for setting up an oxyacetylene station.

CRITERION - REFERENCE MEASURE

The student will set up an oxyacetylene station properly. The student will identify and explain each part and/or operation including the proper pressures.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chaper 9
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

To set up the oxyacetylene equipment properly and safely, the operator must be completely aware of the procedure to follow. There are hazards involved so precautions are necessary. The system must be purged to clear away foreign particles. Special-type threads are involved which can only be attached at the proper places to prevent costly damage and insure safe operation.

Presentation Outline	Activities
I. Safety II. Equipment	1. Secure cylinders, remove caps to purge, and crack valve to purge. 2. Attach regulators to cylinder valves, relieve diaphram, open valve ½ turn, turn in tee handle to purge regulator, and set pressure at ten pounds. 3. Identify oxygen and acetylene regulator by color. 4. Attach red hose to acetylene and purge. 5. Attach green hose to oxygen regulator and purge. 6. Attach torch body and tip purge.

REVIEW POINTS

1. Cylinders should always be transported and used in the upright position. (True or false)
2. Oxygen and acetylene hoses have right and left hand threads and must be connected to the proper places. (True or false)
3. The cylinder valve is cracked to: (check one)
   a) let off excess pressure.
   b) remove foreign particles
4. A more even flow of gas can be expected from a: (check one)
   a) two-stage regulator
   b) single-stage regulator
5. Aceytlene becomes an unstable gas compressed at more than: (check one)
   a) 45 lbs
   b) 30 lbs
   c) 15 lbs
   d) 5 lbs
6. What is used to check for leaks?
7. Check the items which make up the major parts of the torch.
   a) needle valves
   b) dial
   c) tee-handle
   d) body
   e) tip

SAFETY

I. Cylinders
   A. Storage
   B. Handling

II. Purging Equipment

III. Gases
   A. Maximum working pressures
   B. Ventilation

IV. Inspection Procedure

EQUIPMENT

I. Cylinders
   A. Construction of cylinders
   B. Storage and handling of cylinders
   C. Coding system of cylinders

II. Regulators
   A. Construction of regulators
   1. Single-stage regulators
   2. Two-stage regulators
   B. Operation of regulators
      1. Single-stage regulators
      2. Two-stage regulators
   C. Safety devices on regulators

III. Hoses and Torches
   A. Hoses
      1. Color coding system
      2. Type threads
      3. Care and maintenance of hoses
   B. Torches
      1. Needle valves
      2. Torch body
      3. Tips
      4. Care and maintenance of torches

IV. Procedure for Setting Up Equipment

SAFETY PRECAUTIONS FOR OXYGEN AND ACETYLENE
THE DO'S

1. Be very careful when moving any oxygen or acetylene cylinder.
2. Keep oxygen away from oil and grease.
3. Crack cylinders before attaching regulators. (Cracking means opening the valve on a cylinder a little then closing it quickly. This blows out dirt.)
4. Open valve on cylinder slowly after regulator is attached.
5. Be sure all connections are clean and gas connections are tight.
6. Check all connections before lighting the torch.
7. When the regulator is not in use, the adjusting screw should be screwed out until diaphram is free.
8. When the torch flashes back or is burning on the inside, turn needle valve off immediately. (The tip is too close to the work; the tip is not clean; or the oxygen or acetylene is not set to the correct welding or cutting pressure.)
9. Protect the hose from rupture or mechanical damage.
10. Close the cylinders and release the pressure from the regulators and hose when work is completed.
11. Extra tips should be put away when not in use. Never put them in a drawer or with other tools. This may damage the seat of the tip.
12. Use the right size tip for cutting and welding.
13. Turn the oxygen cylinder valve all the way open. This locks the valve.
14. Keep the cylinders in an upright position.
15. Mark the cylinders that have been used--"EMPTY" or "MT."
16. Place the welding tip so that it points to the side of the torch to which the acetylene hose is attached.
17. Close valves on the cylinders and release pressure from regulator and hose when work is completed or at the end of day.

SAFETY PRECAUTIONS FOR OXYGEN AND ACETYLENE
THE DON'TS

1. Do not use oil or grease on any oxygen or acetylene connections. Oil and oxygen will ignite.

2. Never open tank valves unless the regulator valves are closed. (When the regulator is not in use, the adjusting screw should be screwed out until diaphram is free.)

3. Never open the valves on the cylinders with a hammer.

4. Never hammer on oxygen or acetylene regulators.

5. Do not light a torch with a match or open flame. Use lighter provided.

6. Before lighting torch, be certain that hose, tanks, or any inflammable material will not be exposed to heat, flame, or sparks.

7. Beware of high acetylene pressures! Never use acetylene gas when the pressure is greater than 15 lbs. per square inch. (Acetylene gas which has been compressed to more than 15 lbs. becomes a very high explosive.)

8. Never screw the regulator screw in tightly against the regulator. This spoils the diaphram. If hose pressure drops, check tank pressure at regulator as tank is probably empty.

9. Do not hold welding or cutting tip too close to the work. This will cause a flash-back to the torch.

10. Never use a tip that becomes hot.

11. Do not use a torch that leaks.

12. Never leave the torch burning unattended.

13. Do not leave torch valve open.

14. Never cut or weld too close to concrete. Put fire brick next to the work.

15. Do not use the torch for a hammer, crowbar, wedge, or for any other purpose than welding.

16. Do not adjust, alter, change, build, or do any experimental work on cylinders, regulators, torches, or any other gas equipment.

17. Never attempt to weld a closed or jacketed tank, vessel, or container without a vent for air. Even then, great care should be taken not to allow gas in the tank. If for any reason gas gets in the tank, aerate the tank.

18. Do not have butane lighter or book matches in shirt, pants, or jacket pockets.

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Oxyacetylene
Lesson Plan 2

Suggested instructional time
3 class periods

CYLINDER AND GASES

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to demonstrate a basic knowledge of the cylinders and gases by scoring 80% or above on a post test.

CRITERION - REFERENCE MEASURE

The student will explain the characteristics and origin of cylinders, regulators, the torch, acetylene gas, and oxygen, and give the three main advantages of the oxyacetylene process.

REFERENCES

Modern Welding, Chapter 2
Welding Technology, Chapter 7
Welding: Principles and Practices, Chapter 5

INTRODUCTORY STATEMENT

Oxyacetylene is a basic non-pressure of joining metals by fusion alone. In this process, the metal is heated to a molten puddle which flows or fuses together. More metal may be added by melting a rod into the puddle for additional build up. The process has a wide variety of uses in industrial and maintenance operations.

Presentation Outline

I. Oxyacetylene Equipment
   A. Cylinders
   B. Regulators
   D. Hoses
   E. Tips
II. Safety
III. Advantages of the Oxyacetylene Process
   A. Used mostly for light metals
   B. Slow rate of heating and cooling
   C. Low cost

Activities

1. Discuss assigned reading.
   a) Acetylene cylinders
   b) Safety features
   c) Type of threads in cylinder valve
2. Discuss the following:
   a) Wall thickness of oxygen cylinders
   b) Type of valve double seating
   c) Type of thread valves protected by removable cap

3. Explain the following:
   a) Oxygen and acetylene hose, colors, size, and construction
   b) Type of oxygen and acetylene nuts
   c) Threads
   d) Oxygen regulators and gauges
   e) Types of single and double - stage
4. Explain the principal parts and their functions.
   a) Acetylene regulators
   b) Acetylene gauges
5. Explain the principal parts of torches and their functions.
   a) Injector
   b) Equal pressure
6. Safety

REVIEW POINTS

1. Name the process used to produce pure oxygen.
2. At what temperature does oxygen show the most accurate pressure?
3. Where was the process first discovered?
4. Like acetylene, oxygen is also a highly combustible gas. (True or false)
5. The oxyacetylene process is very limited in its application. (True or false)
6. Name three distinct hazards to be guarded against in the oxyacetylene process.
7. Name the main pieces of equipment needed in order to assemble a complete oxyacetylene welding outfit.

CYLINDER CARE

1. Couple the correct pressure-reducing regulators to oxygen or acetylene cylinder valves. Never interchange oxygen and acetylene regulators. Oxygen and acetylene cylinder manifold units already have regulators included in the assembly.

2. Open oxygen and acetylene valves slowly at first so regulators and pressure gauges won't be damaged.

3. Stand to one side of regulator gauges when cylinder valve is opened.

4. Oxygen cylinder valves should be opened fully when in use. Acetylene cylinder valves should be opened only 1/2 turns.

5. Avoid storing oxygen cylinders near a source of heat. Rising temperatures increase the pressure of oxygen within the cylinder and may cause the safety valve to open and let the oxygen escape.

6. Oxygen cylinders should not be stored near reserve acetylene cylinders or other types of fuel gas or inflammable materials, oil, grease, etc.

7. If cylinders must be stored in the open, protect them from accumulations of snow and ice and from direct, hot sunlight.

8. Cylinders should be secured at all times so they can't be knocked over. Unless a tank truck is used, apparatus should not be left attached when cylinders are being moved.

9. Do not allow live wires or ground wires to come in contact with cylinders. Never strike an arc on a cylinder.

10. Never use a hammer or wrench to open oxygen cylinder valves; open them by hand. Acetylene cylinder valves should be opened with the wrench or key supplied for that purpose.

11. Never make a storage place out of the recessed top of an acetylene cylinder.

12. Close all cylinder valves when work is completed. This applies to empty cylinders as well.

13. Cylinders should be used in the order they're received from the supplier. Empties should be returned promptly to reduce rental charges.

14. Never use cylinders as rollers to bear loads.

Oxyacetylene
Lesson Plan 3

Suggested instructional time
6 class periods

LIGHTING AND ADJUSTING FLAME AND CLOSING STATION

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to light, adjust to the three flames, shut off the torch and close down the oxyacetylene station following the correct procedure and safety precautions. The procedure must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will demonstrate and expain the three types of flames and the procedure for lighting the torch. Each step for lighting and closing the station must be explained and demonstrated.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 9
Welding: Principles and Practice, Chapter 5

INTRODUCTORY STATEMENT

In the oxyacetylene process, the three main operations are heating, welding, and cutting. The student must know the correct procedure and the type of flame needed for a particular operation.

Presentation	Activities
I. Lighting Torch A. Cylinder valve operations B. Regulator working pressure adjustment C. Torch needle valves D. Procedure for lighting torch II. Adjusting Flame A. Neutral flame B. Carburizing flame C. Oxidizing flame	1. Demonstrate proper procedures for lighting and adjusting flame and cutting off torch. 2. Have students light torch and adjust to a neutral flame. 3. Follow the procedure for lighting torch, adjusting flame, shutting off torch, and closing down station a shown on Supplement.

III. Shutting Off Torch and Closing Down Station
   A. Procedure for shutting off torch
   B. Procedure for closing down station

REVIEW POINTS

1. When opening the cylinder valve always stand: (check one)
   a) behind regulator
   b) to one side of regulator
   c) in front of regulator
2. The acetylene needle valve should be opened until the flame: (check one)
   a) jumps off the end of the tip
   b) quits smoking
3. To shut the torch off, always turn the: (check one)
   a) oxygen off first
   b) acetylene off first
4. An oxidizing flame is one that has excess acetylene. (True or false)
5. In shutting the station down, always relieve the regulator diaphram first. (True or false)
6. How far should the acetylene valve be opened?

PROCEDURE IN LIGHTING TORCH, ADJUSTING FLAME, SHUTTING OFF TORCH, AND CLOSING DOWN STATION

1. Relieve oxygen and acetylene regulator diaphrams.
2. Close torch needle valves.
3. Turn oxygen cylinder valve full open.
4. Turn acetylene cylinder valve 3/4 turn. Note that acetylene cylinder valve should never be turned more than 1 1/2 turns.
5. Adjust oxygen regulator to 10 psi or given pressure.
6. Adjust acetylene regulator to 6 psi or given pressure.
7. Turn acetylene needle valve 1/8 to 1/4 open.
8. Ignite torch with a spark lighter.
   NOTE: Make sure torch is always turned away from other persons or equipment. Never light torch with a flame.
9. Open acetylene needle valve until smoke disappears.
10. Open oxygen needle valve until desired flame results.
11. Close acetylene needle valve.
12. Close oxygen needle valve.

Closing Down Station

1. Close oxygen and acetylene cylinder valves.
2. Open torch needle valves and bleed pressures.
3. Close torch needle valves.
4. Turn regulator screws counter-clockwise until loose.

PRECAUTIONS IN LIGHTING TORCHES

1. Never use a match to light a torch. The flame can reach 6000° degrees F. ! Use a tripl-flint spark lighter and follow safety instructions.

2. Do not attempt to relight a torch from the hot metal--particularly in a confined area. Gases do not always relight immediately from hot metal and an explosion could result. Use the tripl-flint spark lighter.

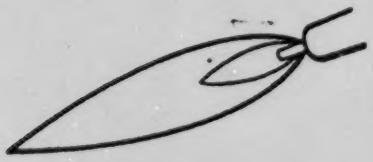
3. Follow the manufacturer's instructions carefully when lighting and adjusting torches. Use recommended pressures for the torch and tip.

4. Never hang the torch and hose on cylinder valves or regulators. The weight of the torch and hose can damage regulators or keep cylinder valves from closing quickly.

5. Be sure there are no obstacles between the cylinders and the work area. The cylinders must be accessible in case of emergency.

6. Do not use acetylene at pressures above 15 psi.

OXYACETYLENE FLAME



CARBURIZING FLAME
(Excess Acetylene)

NEUTRAL FLAME

OXIDIZING FLAME
(Excess Oxygen)

Oxyacetylene
Lesson Plan 4

Suggested instructional time
6 class periods

CARRY PUDDLE WITHOUT FILLER ROD

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to establish the molten puddle and demonstrate the correct procedure for running straight even beads without filler metal in the flat, vertical, horizontal, and overhead positions. The beads must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will give the procedure for and demonstrate establishing the molten puddle. The student will explain the effect that bead width has on fusion and the effect of torch angle on heat input. The student will explain the procedure and carry the puddle in the following positions: flat, horizontal, vertical, and overhead.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

In this lesson, the student will actually perform the first basic steps in welding of carrying the puddle without filler rod. If the student follows the basic instructions and the instructor's demonstration, no great difficulty should develop in mastering this important exercise.

Presentation Outline	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit III. Procedure	Demonstrate using the following procedure. 1. Check to make sure all safety equipment is in good working order. 2. Set up equipment and adjust regulators. 3. Light torch and adjust to neutral flame.

4. Position 6" x 6" plate on fire brick so that it is not laying directly against surface.
5. Direct flame at 35° to 45° angle with no side angle. Do not let white cone touch metal.
6. Manipulate torch with a slight circular motion to establish puddle.
7. Move torch only as fast as a uniform puddle can be maintained.
8. If at first beads cannot be carried in a straight line, scratch line with scribe and straight edge.

REVIEW POINTS

1. Pliers are used to: (check one)
   a) hold work piece in place
   b) change tip
   c) handle hot metal

2. Equal amounts of oxygen and acetylene produce a _____ flame.

3. The less that the torch angle is in relation to the work piece, the greater is the heat input. (True or false)

4. In the forehand technique, the weld progresses from right to left. (True or false)

Oxyacetylene
Lesson Plan 5

Suggested instructional time
30 class periods (minimum)

CARRYING THE PUDDLE WITH FILLER ROD

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to demonstrate the proper procedure for carrying the puddle with filler metal in the flat, horizontal, vertical, and overhead positions. The procedure must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will select the proper size tip to be used on a given thickness of metal and the proper filler rod for a given metal. The student will explain and demonstrate the proper rod and torch angles. The student will explain the procedure and demonstrate carrying the puddle with filler metal in the flat, horizontal, vertical, and overhead positions.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

After running beads or carrying puddle **without** filler metal, running beads **with** filler rod is the next step in the process. This exercise requires the coordination of both hands to form the proper type weld beads. Torch and rod angle and the manipulation of torch and rod are most important in this exercise.

Presentation	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit III. Material A. Sheet steel--light gauge steel strip (6" x 6") B. 3/32" diameter mild steel filler rod IV. Procedure	Demonstrate the following procedure. 1. Set up and adjust to desired setting; usually about 10 psi oxygen and 10 psi acetylene. 2. Light torch and adjust to a flame. 3. Position plate so it does not lay snug against fire brick.

4. Establish puddle with torch angle 35° to 45° and no side angle.
5. Position filler rod 35° to 45° and apply to leading edge of puddle.

REVIEW POINTS

1. A spark lighter is considered to be safety equipment. (True or false)
2. The filler metal should be the same composition as the base metal. (True or false)
3. Why is it important to have a neutral flame?
4. Why should the work piece not lay flat on the fire brick?
5. Is it likely for the regulator settings to affect the adjustment of the flame?

Oxyacetylene
Lesson Plan 5

Suggested instructional time
15 class periods

LIGHT GAUGE METALS (FLAT POSITION)

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld the butt, lap, tee fillet, and outside corner joint in the flat position. The weld must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will assemble five strips to form the four joint work pieces. Explain the procedure and demonstrate welding the butt joint, lap joint, tee fillet joint, and outside corner joint with filler metal.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

The student should be ready to begin welding light gauge metal strips together with a filler rod. The work piece will consist of a four-joint assembly to be done in the four main welding positions. In this exercise, the torch and rod angle will vary according to the position of the work piece and type of joint being done.

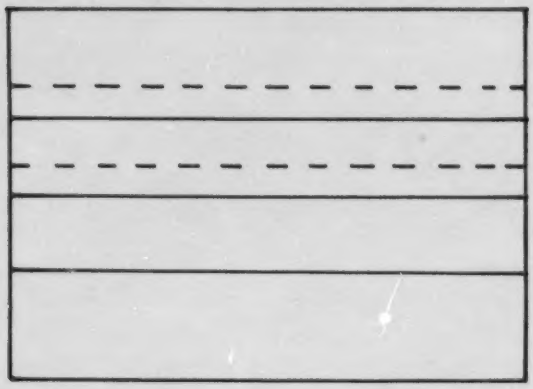
Presentation	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit (including light gauge steel strip--1 1/4" x 6") III. Procedure	Demonstrate the following procedure. 1. Check safety equipment to make sure it is in proper working condition. 2. Set up equipment and adjust regulators (10 lbs. oxygen and 10 lbs. acetylene). 3. Light torch and adjust to a soft neutral flame.

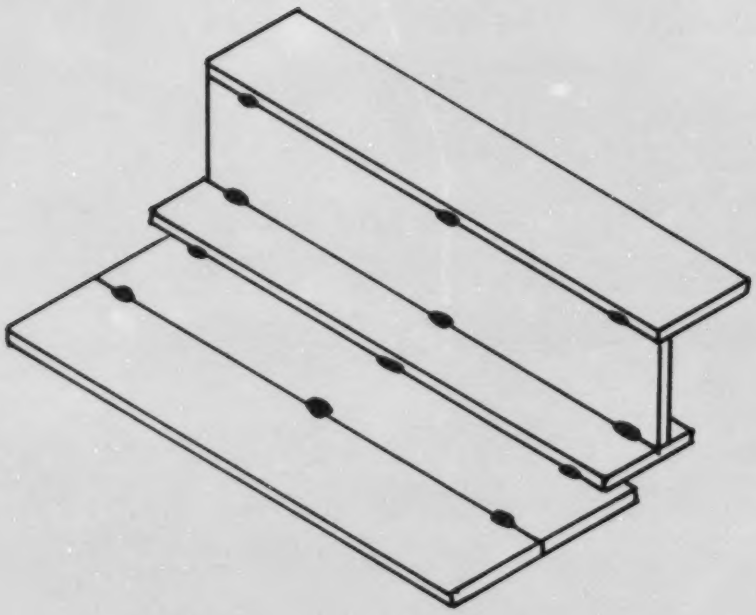
4. Assemble 1 1/4" x 6" gauge strips to form a four-joint work piece. See following drawing.
5. Position work piece on fire brick so there is nothing directly under the weld area.
6. Direct flame at a 35° to 45° angle to work piece with no side angle.
7. Manipulate rod and torch to form even ripples and uniform weld beads.
8. Travel speed should be slow enough to insure good penetration.
9. Complete at least five work pieces in each position.
10. Consult reference for correct torch angle for all four weld joints.

REVIEW POINTS

1. Rod and torch angles are of little consequence in doing the exercise. (True or false)
2. The diameter of the filler metal should be: (check one)
   a) 3/16"
   b) 1/8"
   c) 1/16"
   d) 3/32"
3. Short pieces of filler rod are to be: (check one)
   a) thrown away
   b) welded together and used
4. Moving the torch too slow or too fast causes_____ weld beads.
5. What angle does a tee joint form?

FLAT POSITION





FLAT POSITION

Oxyacetylene
Lesson Plan 7

Suggested instructional time
15 class periods

LIGHT GAUGE METALS (HORIZONTAL)

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld the butt, lap, tee fillet, and outside corner joint in the horizontal position. The weld must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will assemble five strips to form the four joint work pieces. Explain the procedure and demonstrate welding the butt joint, lap joint, tee fillet joint, and outside corner joint with filler metal.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

The student should be ready to begin welding light gauge metal strips together with a filler rod. The work piece will consist of a four-joint assembly to be done in the four main welding positions. In this exercise, the torch and rod angle will vary according to the position of the work piece and type of joint being done.

Presentation Outline

I. Safety Equipment
II. Oxyacetylene Welding Outfit (including light gauge steel strip-1 1/4" x 6")
III. Procedure

Activities

Demonstrate the following procedure.

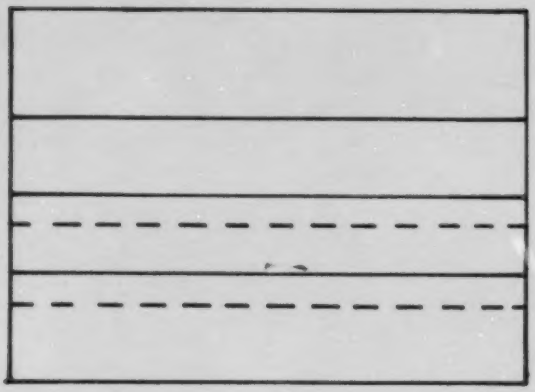
1. Check safety equipment to make sure it is in proper working condition.
2. Set up equipment and adjust regulators (10 lbs. oxygen and 10 lbs. acetylene).
3. Light torch and adjust to a soft neutral flame.

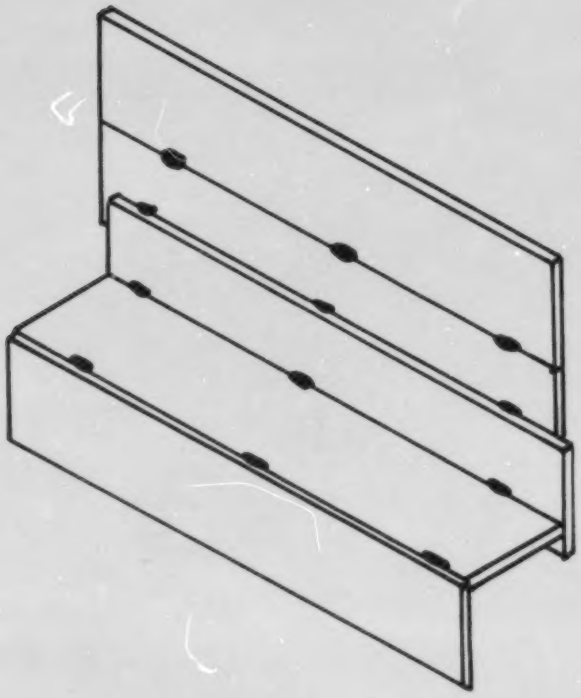
4. Assemble 1 1/4" x 6" gauge strips to form a four-joint work piece. See following drawing.
5. Position work piece on fire brick so there is nothing directly under the weld area.
6. Direct flame at a 35° to 45° angle to work piece with no side angle.
7. Manipulate rod and torch to form even ripples and uniform weld beads.
8. Travel speed should be slow enough to insure good penetration.
9. Complete at least five work pieces in each position.
10. Consult reference for correct torch angle for all four weld joints.

REVIEW POINTS

1. Rod and torch angle are of little consequence in doing the exercise. (True or false)
2. The diameter of the filler metal shoud be: (check one)
   a) 3/16"
   b) 1/8"
   c) 1/16"
   d) 3/32"
3. Short pieces of filler rod are to be: (check one)
   a) thrown away
   b) welded together and used
4. Moving the torch too slow or too fast causes_____weld beads.
5. What angle does a tee joint form?

HORIZONTAL POSITION





HORIZONTAL POSITION

Oxyacetylene
Lesson Plan 8

Suggested instructional time
15 class periods

LIGHT GAUGE METALS (VERTICAL POSITION)

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld the butt, lap, tee fillet, and outside corner joint in the vertical position. The weld must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will assemble five strips to form the four joint work pieces. Explain the procedure and demonstrate welding the butt joint, lap joint, tee fillet joint, and outside corner joint with filler metal.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

The student should be ready to begin welding light gauge metal strips together with a filler rod. The work piece will consist of a four-joint assembly to be done in the four main welding positions. In this exercise, the torch and rod angle will vary according to the position of the work piece and type of joint being done.

Presentation Outline	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit (including light gauge steele strip–1 1/4" x 6") III. Procedure	Demonstrate the following procedure. 1. Check safety equipment to make sure it is in good working condition. 2. Set up equipment and adjust regulators (10 lbs. oxygen and 10 lbs. acetylene). 3. Light torch and adjust to a soft neutral flame.

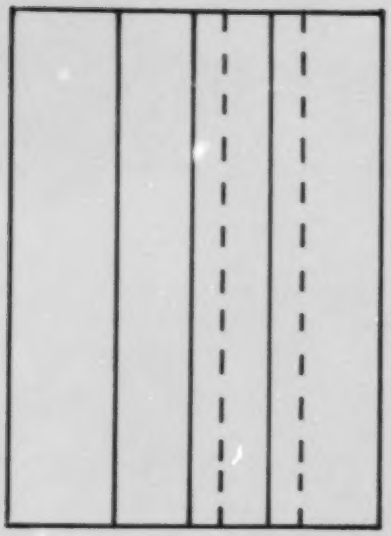
4. Assemble 1 1/4" x 6" gauge strips to form a four-joint work piece. See following drawing.
5. Position work piece on fire brick so there is nothing directly under the weld area.
6. Direct flame at a 35° to 45° angle to work piece with no side angle.
7. Manipulate rod and torch to form even ripples and uniform weld beads.
8. Travel speed should be slow enough to insure good penetration.
9. Complete at least five work pieces in each position.
10. Consult reference for correct torch angle for all four weld joints.

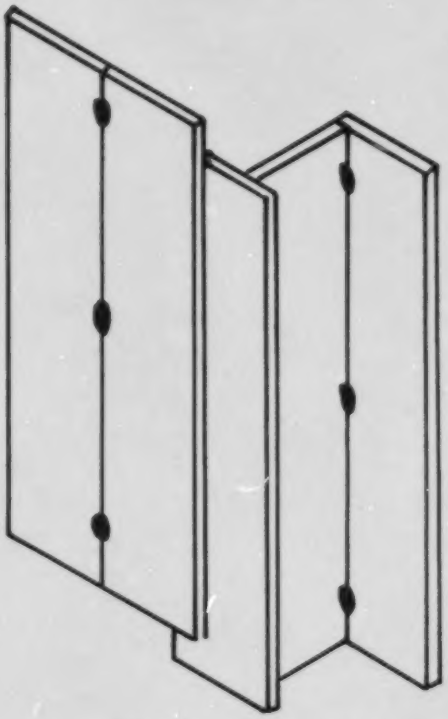
REVIEW POINTS

1. Rod and torch angle are of little consequence in doing the exercise. (True or false)
2. The diameter of the filler metal should be: (check one)
   a) 3/16"
   b) 1/8"
   c) 1/16"
   d) 3/32"
3. Short pieces of filler rod are to be: (check one)
   a) thrown away
   b) welded together and used
4. Moving the torch too slow or too fast causes _____ weld beads.
5. What angle does a tee joint form?

52

VERTICAL POSITION





VERTICAL POSITION

Oxyacetylene
Lesson Plan 9

Suggested instructional time
15 class periods

LIGHT GAUGE METALS (OVERHEAD POSITION)

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld the butt, lap, tee fillet, and outside corner joint in the overhead position. The weld must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will assemble five strips to form the four-joint work pieces. Explain the procedure and demonstrate welding the butt joint, lap joint, tee fillet joint, and outside corner joint with filler metal.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

The student should be ready to begin welding light gauge metal strips together with a filler rod. The work piece will consist of a four-joint assembly to be done in the four main welding positions. In this exercise, the torch and rod angle will vary according to the position of the work piece and type of joint being done.

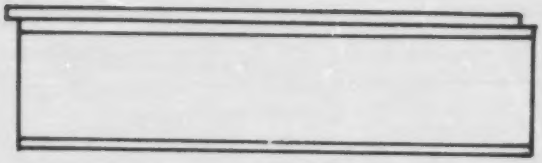
Presentation Outline	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit (including light gauge steele strip-1 1/4" x 6") III. Procedure	Demonstrate the following procedure. 1. Check safety equipment to make sure it is in proper working condition. 2. Set up equipment and adjust regulators (10 lbs. oxygen and 10 lbs. acetylene). 3. Light torch and adjust to a soft neutral flame.

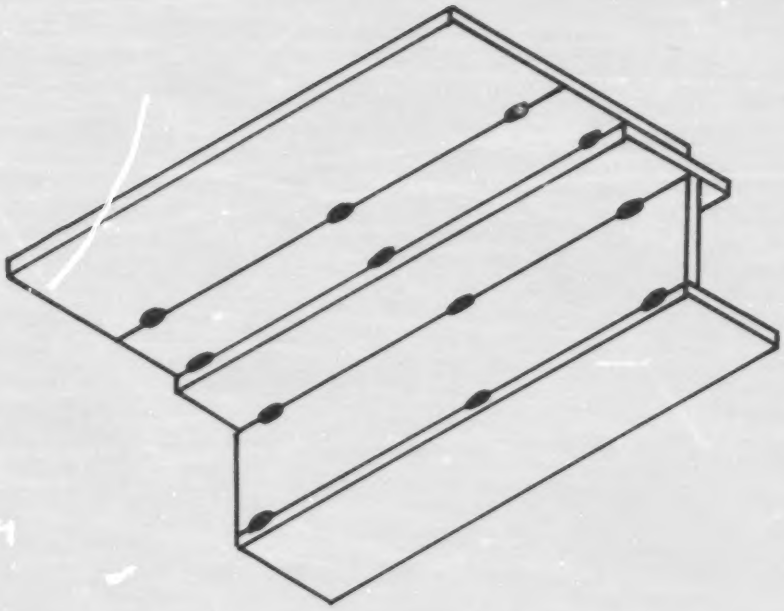
4. Assemble 1 1/4" x 6" gauge strips to form a four-joint work piece. See following drawing.
5. Position work piece on fire brick so there is nothing directly under the weld area.
6. Direct flame at a 35° to 45° angle to work piece with no side angle.
7. Manipulate rod and torch to form even ripples and uniform weld beads.
8. Travel speed should be slow enough to insure good penetration.
9. Complete at least five work pieces in each position.
10. Consult reference for correct torch angle for all four joints.

REVIEW POINTS

1. Rod and torch angle are of little consequence in doing the exercise. (True or false)
2. The diameter of the filler metal should be: (check one)
   a) 3/16"
   b) 1/8"
   c) 1/16"
   d) 3/32"
3. Short pieces of filler rod are to be: (check one)
   a) thrown away
   b) welded together and used
4. Moving the torch too slow or too fast causes_____ weld beads.
5. What angle does a tee joint form?

OVERHEAD POSITION





OVERHEAD POSITION

Oxyacetylene
Lesson Plan 10

Suggested instructional time
3 class periods

SETTING UP CUTTING EQUIPMENT

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to set up a complete oxyacetylene cutting outfit following the proper sequence and safety precautions with 95% accuracy.

CRITERION - REFERENCE MEASURE

The student will describe the cutting tips used in oxyacetylene cutting and the process of oxidating in oxyacetylene cutting. The student will describe and demonstrate setting up the oxyacetylene cutting station and lighting and adjusting the cutting torch flame. The student will state the safety precautions to be observed in setting up the oxyacetylene cutting station.

REFERENCES

Modern Welding, Chapter 3
Welding Technology, Chaper 12
Welding: Principles and Practices, Chapter 16

INTRODUCTORY STATEMENT

Oxyacetylene cutting is a convenient way of cutting metal out of the shop. The art of oxyacetylene cutting has progressed rapidly and it is now possible to accurately cut both thin and thick metal.

Presentation Outline	Activities
I. Cylinders II. Cylinder Color III. Gases (Characteristics) IV. Hose Color and Connections V. Gauges and Regulators VI. Cutting Torch VII. Setting Up Equipment VIII. Oxidation	1. Demonstrate setting up equipment and check for leaks. 2. Have students demonstrate their ability to set up and check equipment for leaks.

REVIEW POINTS

1. Describe the process used in setting up and checking equipment for leaks.
2. From what type of material is the cutting tip made?
3. Why are the cutting tip and seat constructed to produce a good flow of gas?
4. What is the purpose of the outer holes in the cutting tip?
5. What is the purpose of the center holes in the cutting tip?
6. What are these holes called?
7. Name two types of regulators.
8. Why should the oxygen cylinder valves be opened all the way when in use?
9. Which cylinder is equipped with left-hand thread?
10. Visually, how are the acetylene connecting nuts distinguished from oxygen connecting nuts?

Oxyacetylene
Lesson Plan 11

Suggested instructional time
6 class periods

MAKING SQUARE CUTS ON STEEL PLATES

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to make square cuts on 3/16" to 3/4" steel plates with 90% accuracy.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate the principle of preheating the metal before making a cut and the procedure for laying out the lines on the metal. The student will explain the reasons for the selection of a particular cutting tip, the reasons for the selection of the working pressures of the gases in cutting a given thickness of metal, and the approximate torch speed in making a square cut on a given thickness of metal. The student will explain the safety precautions to be observed and the proper procedure for making square cuts on 3/16" to 3/4" steel plates.

REFERENCES

Modern Welding, Chapter 3
Welding Technology, Chapter 12
Welding: Principles and Practices, Chapter 16

INTRODUCTORY STATEMENT

Before metal can be cut with the oxyacetylene flame, a chemical reaction must take place. This reaction is called oxidation. When the metal has been heated to a kindling point and the oxygen jet has been opened, there is a chemical reaction in the metal and the pressure from the oxygen jet blows the metal away. This makes the metal rust and is blown away with the compressed oxygen.

Presentation Outline	Activities
I. Safety Precautions	1. Demonstrate how to set working pressure.
II. Safety Clothing	2. Light torch and demonstrate the three flames.
III. Set Working Pressure	3. Adjust torch for proper flame.
IV. Light Torch and Demonstrate Flame	
V. Prepare Metal to be Cut	

VI. Measuring and Marking Tools
VII. Making Square Cut on Steel Plate

4. Make square cut.
5. Explain what is meant by "drag."
6. Have students demonstrate the cutting procedure.

REVIEW POINTS

1. Name ten safety precautions in oxyacetylene cutting.
2. Name the three acetylene flames.
3. What is a carburizing flame?
4. What is the oxygen pressure when cutting 1/4" metal?
5. Define oxidation.
6. Match the correct cutting tip with the correct metal thickness.

METAL THICKNESS	TIP NUMBER
a) 1/4"	2
b) 3/4"	3
c) 1 1/2"	5
d) 1/8"	3
e) 3"	3

METAL THICKNESS	OXYGEN PRESSURE	0 ACETYLENE PRESSURE	SPEED INC. PER. MIN.
1/8" - 3/8"	20-30	3	14"-18"
3/8" - 3/4"	30-40	5	12"-15"
3/4" - 1"	40-45	5	10"-12"
1 1/2" - 2"	45-50	5	9"-10"

METAL THICKNESS	MECO TIP NUMBER
1/8"	0
1/4"	1
3/8"	1
1/2"	2
3/4"	2
1"	2
1 1/2"	3
2"	3
3"	3
4"	4
5"	4
6"	5

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6. Raise torch 1/2" above metal, even oxygen jet, and proceed following line of cut.
7. Have students set up, clean, measure, mark, and make piercing cut.

REVIEW POINTS

1. What is the procedure for piercing holes?
2. What is the purpose of raising the cutting tip 1/2" above metal before opening the oxygen jet?
3. How should preheat and cutting orifice be cleaned?
4. Name the three valves on the cutting torch.
5. Of what type metal is the body of the torch made?

Oxyacetylene
Lesson Plan 12

Suggested instructional time
6 class periods

MAKING PIERCING CUT ON STEEL PLATE

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to make piercing cuts on steel plates with 90% accuracy.

CRITERION - REFERENCE MEASURE

The student will demonstrate the procedure for laying out the metal. The student will explain the reasons for the selection of a particular cutting tip and for the selection of the working pressures of the gases in making a piercing cut on a given thickness of metal. The student will explain the safety precautions to be observed and the proper procedure for making piercing cuts on steel plates.

REFERENCES

Modern Welding, Chapter 3
Welding Technology, Chapter 12
Welding: Principles and Practices, Chapter 16

INTRODUCTORY STATEMENT

Piercing metal with the oxyacetylene flame is not a new method of cutting. This operation is old as the oxyacetylene flame. Piercing is done in all types of fabrications inside and outside the shop area. The difference in piercing metal and cutting a straight line is torch manipulation.

Presentation Outline	Activities
I. Safety Procedure	1. Select and clean metal to be pierced.
II. Safety Apparel	2. Measure and make center of hole to be cut.
III. Selection of Metal	3. Use center punch, scribe, or soapstone to make line of cut.
IV. Measuring and Making Tools	4. Light and adjust flame.
V. Setting Regulator Working Pressure	5. Preheat metal to kindling point.
VI. Light Torch/Make Piercing Cut	

Oxyacetylene
Lesson Plan 13

Suggested instructional time
6 class periods

CIRCULAR CUTTING ON STEEL PLATE

OBJECTIVE

Given necessary equipment and instruction, the student will be able to make circular cuts on steel plates with 90% accuracy.

CRITERION - REFERENCE MEASURE

The student will demonstrate the procedure for laying out the lines on the metal. The student will explain the reasons for the selection of a particular cutting tip and for the selection of the working pressures of the gases in cutting a given thickness of metal. The student will give the approximate torch speed in making a circular cut on a given thickness of metal. The student will explain the safety precautions to be observed and the proper procedure for making a circular cut on steel plates.

REFERENCES

Modern Welding, Chapter 3
Welding Technology, Chapter 12
Welding: Principles and Practices, Chapter 16

INTRODUCTORY STATEMENT

Circles and discs can be cut accurately with a hand torch using the circle guide attachment. Without the attachment, it is most difficult to cut circles accurately.

Presentation Outline	Activities
I. Safety Procedure	1. Clean, measure, and mark circle
II. Safety Apparel	2. Make circular cut free-hand.
III. Material	3. Make circular cut using torch circle guide.
IV. Measuring and Marking Tools	4. Have students prepare, mark, and make free-hand circle cut (2" diameter circle).

5. Have students prepare, mark, and make circular cut using the torch circle guide (9" and 12" diameter circle).

REVIEW POINTS

1. Lay out and cut 2" diameter circle (free-hand).
2. Lay out and cut 9" diameter circle using the torch circle guide.
3. Lay out and cut a 12" disc using the torch guide.
4. What is known as waste plate?
5. Why should the cut be started on the waste plate?

Oxyacetylene
Lesson Plan 14

Suggested instructional time
3 class periods

MAKING BEVEL CUTS ON STEEL PLATE

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to make bevel cuts on steel plates.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate the proper procedure for making bevel cuts on steel plates by laying out the lines on the metal, selecting a particular cutting tip, and selecting the working pressure of the gases in cutting a given thickness of metal. The student will give the approximate torch speed in making a bevel cut on a given thickness of metal. The student will explain the safety precautions to be observed in making bevel cuts on steel plates.

REFERENCES

Modern Welding, Chapter 3
Welding Technology, Chapter 12
Welding: Principles and Practices, Chapter 16, p. 483

INTRODUCTORY STATEMENT

Bevel cutting is a very important operation because metal 1/4" and above must have a bevel edge to get good penetration. This method is always used for fabrication.

Presentation Outline	Activities
I. Safety Precautions II. Safety Apparel III. Measuring and Marking IV. Prepare Metal for Bevel Cut V. Make Bevel Cut A. Set gas working pressure B. Select correct cutting tip C. Light torch	Demonstrate the following procedure. 1. Measure and lay out angle to be cut. 2. Set working pressure. 3. Light torch and adjust to neutral flame. 4. Make bevel cut.

D. Adjust to neutral flame
E. Preheat metal
F. Hold torch at 45° angle
G. Open oxygen jet
H. Proceed with bevel at proposed line of cut

Have student measure and make bevel cut.

REVIEW POINTS

1. What safety precautions must be considered before starting a flame cutting operation?
2. What is the name of the slot created by a cutting jet?
3. How do you determine when to open the oxygen cutting jet?
4. Which is the best word to describe this process?
   a) flame cutting
   b) burning

Oxyacetylene
Lesson Plan 15

Suggested instructional time
3 class periods

PIPE BEVELING

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to bevel pipe with oxyacetylene equipment.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate the proper procedure for making a beveling pipe on steel plates by laying out the lines on the metal, selecting a particular cutting tip, selecting the working pressure of the gases, and giving the approximate torch speed in making a beveling pipe on a given thickness of metal. The student will explain the safety precautions to be observed in making a beveling pipe on steel plates.

REFERENCES

Welding: Principles and Practices, Chapter 16

INTRODUCTORY STATEMENT

Beveling pipe with the oxyacetylene flame is a skill that can be perfected only with practice. When fitting pipe, the oxyacetylene torch operation is the major factor.

Presentation Outline	Activities
I. Safety Procedure	1. Select and clean pipe.
II. Personal Safety	2. Measure and mark line of cut.
III. Preparations	3. Set regulator working pressure.
IV. Cutting Tip	4. Light torch and adjust flame.
V. Procedure	5. Bevel pipe along line of cut while pipe is being rolled.
A. Set regulator working pressure	
B. Light torch in usual manner	
C. Angle of torch	
D. Speed of travel	

REVIEW POINTS

1. Name five safety factors in oxyacetylene cutting.
2. Why is the flint striker more safe to use than an open flame?
3. What is a wrap-around?
4. Twenty percent more working pressure is required when doing bevel work. (True or false)
5. The torch valves should be closed when setting working pressure. (True or false)

RECOMMENDED FOR

ADVANCED OXYACETYLENE

Oxyacetylene
Lesson Plan 16

Suggested instructional time
6 class periods

WELDING OUTSIDE CORNER ON HEAVY GAUGE METAL

OBJECTIVE

Given necessary equipment and instruction, the student will be able to demonstrate outside corner weld on heavy gauge metal in the flat, horizontal, vertical, and overhead positions.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate the proper set-up of work pieces. The student will explain the procedure and demonstrate the outside corner weld in the flat, horizontal, vertical, and overhead positions.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

The procedure discussed in this lesson concerns the welding of heavier gauge metal which requires more heat, larger tip size, and a different rod and torch angle.

Presentation Outline	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit A. Cylinders B. Regulators C. Torch D Hose III. Material A. Sheet metal (11 gauge, 2" x 9" strips) B. Filler rod (1/8" diameter, mild steel)	1. Set up and adjust equipment to desired setting. 2. Light torch and adjust to neutral flame. 3. Position 11-gauge strips to form outside corner. 4. Establish puddle with torch 45° to 60° angle and side angle, according to instructor's specifications. 5. Manipulate torch and rod with even rhythm to form

uniform ripple and bead width.

6. Continue until good penetration and uniform beads are achieved.

REVIEW POINTS

1. Explain the proper set up of work pieces.
2. Describe the procedure for the outside corner weld in each of the four positions.

Oxyacetylene
Lesson Plan 17

Suggested instructional time
15 class periods

VEE-GROOVE BUTT JOINTS ON LIGHT STEEL PLATES

OBJECTIVE

Given necessary equipment and instruction, the student will be able to demonstrate the proper vee-grove butt weld on light plate in the flat, horizontal, vertical, and overhead positions.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate the procedure for the proper set up of the work piece. The student will explain the procedure and demonstrate the vee-grove butt joint in the flat, horizontal, vertical, and overhead positions.

REFERENCES

Modern Welding, Chapter 1
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

To weld the vee-grove butt joint, two passes and a somewhat hotter flame are required than that in the previous lessons. The coordination of both hands is required to make a weld joint with good penetration and a uniform weld base.

Presentation Outline	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit III. Materials A. Steel plate (3/16" x 2" x 6") B. Welding rod, same composition as base metal (1/8" or 3/32") IV. Procedure	1. Set up and adjust equipment to the desired setting. 2. Light torch and adjust to neutral flame. 3. Bevel 3/16" x 2" x 6" plate at a 30° angle. 4. Position pieces 1/8" apart on fire brick and tack-weld 1" from each end in flat position. 5. Establish puddle at end of groove and proceed to weld from right to left.

6. Keep keyhole open and apply filler rod at regular intervals to maintain even penetration.
7. Run finish or second pass to bring weld bead up to the desired height and width.
NOTE: The finish bead may require less flame than the root pass.

REVIEW POINTS

1. What are the four main joints in welding?
2. What is the proper degree of bevel for the vee-grove butt joint?
3. Complete the procedure and test in vise by the destructive testing method.

Oxyacetylene
Lesson Plan 18

Suggested instructional time
6 class periods

WELDING BUTT JOINTS ON 1 1/2" AND 2" STANDARD BLACK PIPE

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld small diameter (1 1/2" and 2") pipe in the horizontal roll position.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the set-up of the work pieces. After identifying the types of pipe, the student will demonstrate the procedure in welding small diameter pipe in the horizontal roll position.

REFERENCES

Modern Welding, p. 474
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17

INTRODUCTORY STATEMENT

The technique of welding pipe in the horizontal roll position is different from that of the preceding exercise on beveled plate. This procedure has several advantages over the others in that it eliminates costly and bulky fittings, is easier to insulate, is a mobile unit, and has better maintenance. A properly welded joint is as strong as the pipe.

Presentation Outline	Activities
I. Safety Equipment	1. Check safety equipment and set up to desired setting.
II. Oxyacetylene Welding Outfit	2. Clean and bevel pipe to 30° angle.
III. Materials	3. Stand pipe together with bevels together.
A. Black stand pipe (2 pieces, 12" long, 1 1/2" and 2" diameter)	4. Space pipe with short welding wire 1/8" diameter, bent in v-shape.
B. Filler rod (3/32" or 1/8" mild steel)	

5. Light torch and adjust to neutral flame.
6. Put one small tack between open ends of wire spacer.
7. Remove spacer and put two more small tacks at an equal distance around pipe maintaining proper space of 1/8".
8. Locate pipe in convenient place to weld and fix in the horizontal position. Begin the weld at about three o'clock and rotate pipe to keep the molten puddle in that area. Complete weld by rotating pipe with one pass.

REVIEW POINTS

1. Backhand welding is sometimes necessary for welding pipe joint. (True or false)
2. How many tack welds are required? What is the size of each?
3. What should the size of the root opening be?

Oxyacetylene
Lesson Plan 19

Suggested instructional time
15 class periods

WELDING PIPE 1 1/2" and 2" DIAMETER IN THE HORIZONTAL, VERTICAL, AND 45° FIXED POSITIONS

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld fixed pipe in the horizontal, vertical, and 45° positions.

CRITERION - REFERENCE MEASURE

The student will measure and identify the type of pipe and its wall thickness. The student will prepare the pipe to be welded and weld it in the fixed horizontal, vertical, and 45° position.

REFERENCES

Modern Welding, Chapter 18, p. 474
Welding Technology, Chapter 10
Welding: Principles and Practices, Chapter 17, p. 519

INTRODUCTORY STATEMENT

The technique of welding pipe in the horizontal, vertical, and 45% angle in fixed positions is similar to that of the preceding exercises on welding pipe in a horizontal rolled position. The advantages discussed earlier are the same for this procedure: maintenance, less costly, no bulky fittings, easily insulated and leaves a strong welded joint.

Presentation Outline	Activities
I. Safety Equipment	1. Check safety equipment, set up, and adjust to desired setting.
II. Oxyacetylene Outfit	
III. Materials	
A. Standard black pipe (2 pieces, 12" long, 1 1/2" and 2" diameter)	2. Clean and bevel pipe to 30° angle.
B. Filler rod (3/32" or 1/8" mild steel)	3. Stand pipe vertical with bevels together.
	4. Space pipe with short v-shaped welding wire (1/8" in diameter).

5. Light torch and adjust to neutral flame.
6. Put one small tack between open ends of wire space.
7. Remove spacer and put two more small tacks at an equal distance around pipe maintaining proper spacing.
8. Locate pipe in a convenient place to weld and fix in the horizontal position. Begin the weld at the bottom of the pipe and weld up each way.
9. Angle the torch right or left to keep the keyhole equally in center of pipe.
10. Use the backhand method for the vertical fixed position. Rotate the pipe from right to left.
11. Fix the pipe at a 45° angle. Weld from the bottom upward each way without rotating.

REVIEW POINTS

1. Can tacks be welded out as part of the weld?
2. Identify the root zone.
3. Is it always necessary to maintain the key hole in this type of welding?
4. Why is pipe beveled?

Oxyacetylene
Lesson Plan 20

Suggested instructional time
3 class periods

RUNNING BEADS WITH BRONZE ROD ON STEEL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to run beads with a bronze rod.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate running beads with bronze rods by describing and demonstrating the procedure in setting up the work pieces and giving the characteristics of the bronze filler rod and braze welding.

REFERENCES

Modern Welding, pp. 455-456
Welding Technology, Chapter 11
Welding: Principles and Practices, Chapter 18

INTRODUCTORY STATEMENT

In the process of running beads with a bronze rod on steel, the bond is one of adhesion rather than fusion. Also, a flux is used as a coating on the rod or to the puddle by dipping the hot filler rod into the flux.

Presentation Outline	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit III. Materials A. Steel metal (14 or 11 gauge, 6" x 9") B. Bronze rod (1/8") C. Suitable flux IV. Procedure	1. Set up equipment and adjust to desired settings. 2. Position work piece (11-gauge steel metal) on fire brick in flat position. 3. Light torch and adjust to slightly oxidizing. 4. If uncoated rod is used, apply heat to rod and dip in flux. 5. Heat metal to dull red, then apply filler rod and move puddle along weld areas as rapidly as desired bead width and height will permit.

REVIEW POINTS

1. What are the characteristics of the bronze filler rod?
2. What is the procedure for running beads with bronze rods?

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Oxyacetylene
Lesson Plan 21

Suggested instructional time
6 class periods

BRAZE WELDING ON SHEET STEEL - BUTT, LAP, AND TEE-FILLET JOINTS

OBEJECTIVE

Given the necessary equipment and instruction, the student will be able to weld mild steel using a bronze filler rod. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will describe the necessary procedure, set up the work pieces, and describe the characteristics of braze welding and filler metal.

REFERENCES

Modern Welding, pp. 455-456
Welding Technology, Chapter 11
Welding: Principles and Practices, Chapter 18

INTRODUCTORY STATEMENT

In the braze welding process, the bond aided by flux is one of adhesion rather than fusion. A flux may be already coated on the rod or may be added to the puddle by dipping the hot rod into the flux. Braze welding is accomplished in this lesson by welding butt, lap, and tee-fillet joints on steel metal.

Presentation Outline

I. Safety Equipment
II. Oxycetylene Welding Outfit
III. Materials
  A. Sheet steel strips (11- gauge, 2" x 9")
  B. Bronze filler rod (1/8")
  C. Suitable flux
IV. Procedure

Activities

1. Set up equipment and adjust to desired setting.
2. Clean metal and place in position of fire brick to tack weld.
3. Light torch and adjust to slightly oxidizing flame.
4. Heat rod tip and dip in flux.
5. Heat both pieces near end until dull red.
6. Drop the bronze onto heated area.

7. Manipulate torch until bronze flows evenly to both pieces.
8. Repeat 1 through 8 on opposite end of work piece.
9. Proceed along butt joint as rapidly as the metal will allow and as the desired bead is formed.
10. Repeat procedure for other joints.

REVIEW POINTS

1. A filler metal must have a melting point below that of the base metal. (True or false)
2. One precaution to consider is never to braze weld a metal that will be subjected to high heat. (True or false)
3. Because the metal does not have to be as hot as in fusion weld, there is less possibility of destroying the characteristics of the metal. (True or false)
4. Braze weld is a process that is done at temperatures above: (check one)
   a) 1800°F
   b) 1500°F
   c) 800°F

Oxyacetylene
Lesson Plan 22

Suggested instructional time
6 class periods

BRAZE WELDING ON CAST IRON - BUTT JOINT

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld a brazed butt joint on cast iron. The weld must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student wil explain the procedure and demonstrate braze welding cast iron and explain the characteristics of brazed cast iron.

REFERENCES

Modern Welding, Chapter 18
Welding Technology, Chapter 11
Welding: Principles and Practices, Chapter 18

INTRODUCTORY STATEMENT

Welding cast iron is another step in the braze welding process. Since it requires more preparation, the operator must be more cautious about over heating the base metal. This process of welding cast iron will produce a very strong bond if properly made. There are many uses for this type of joint in maintenance welding.

Presentation Outline

I. Safety Equipment
II. Oxyacetylene Welding Outfit
III. Materials
  A. Cast iron blocks (scrap cut, 1/2" x 2" x 4")
  B Bronze rod (1/8")
  C. Suitable flux
IV. Procedure

Activities

1. Set up and adjust equipment to the desired setting.
2. Clean cast iron pieces and form a double-V butt joint.
3. Position on fire brick allowing 1/8" space between pieces.
4. Light torch and adjust to slightly oxidizing flame.
5. Heat rod tip and dip in flux.

6. Apply heat to work pieces and bring up to dull red.
7. Apply heat, flux, and rod to metal in a droplet.
8. Manipulate heat on bronze until it flows and tins the metal.
9. Continue to dip rod in flux and apply freely to weld arch.
10. Make at least two or three passes to each side of joint, making sure the first one is welded to the root of the weld.
    NOTE: A root pass should be done on each side of groove to help prevent the work piece from drawing out of line. Make sure the weld area is well-tinned.

REVIEW POINTS

1. What are the characteristics of brazed cast iron?
2. What is the procedure for braze welding cast iron?
3. Demonstrate braze welding cast iron.

Suggested instructional time
6 class periods

SOLDERING WITH LEAD

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to properly tin and make a proper soldered joint on thin sheet metal. The soldering must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the process of soldering, the procedure, how to tin a joint, and the temperature required for soldering. The student will explain the purpose of the flux.

REFERENCES

Modern Welding, Chapter 15
Welding: Principles and Practices, Chapter 19

INTRODUCTORY STATEMENT

The soldering process involves joining like metals or unlike metals with another metal which may be unlike to either of the two. When this soldering metal is molten, the molecules combine with the molecules of the base metal to form a very strong bond. Clean metal is of great importance in this method of joining metal together. The soldering metal can be used at a very low temperature because it does not change the heat treatment of parent metals.

Presentation Outline	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit or Adequate Soldering Iron (300-watt) III. Materials A. Steel strips (1/16" x 1 x 4") 1. Stainless steel 2. Copper 3. Brass B. Suitable soldering flux or paste C. No. 1 solder 50 - 50 IV. Procedure	1. Thoroughly clean metals to be soldered. 2. Apply flux to the general area to be soldered. Open flame or soldering iron may be used. 3. Place hot iron firmly against fluxed edge of strip. 4. Apply solder to the edge of iron. Melt off several drops. 5. As solder adheres to metal, move along edge to form a

thin layer well-bonded to the base metal which is called tinning.

6. When both pieces have been tinned, place these edges firmly together. Place heat on top and move seam as solder melts and bonds the pieces together.
7. When the joint is finished, wash to remove flux.

Review Points

1. What is soldering?
2. What sources of heat are used for soldering?
3. What is the purpose of the flux?
4. May a welding torch be used for soldering?
5. In what general range do solders with the higher tin content flow?
6. The chemicals used for cleaning depend on the types of metal to be soldered. (True or false)
7. Soldering is done below what temperature?

Oxyacetylene
Lesson Plan 24

Suggested instructional time
6 class periods

SILVER SOLDERING BY BRAZING FERROUS AND NON-FERROUS METALS

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to silver solder a joint with a silver alloy filler metal. The solder must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the process and procedure for silver soldering. The student will describe the characteristics of silver solder.

REFERENCES

Modern Welding, Chapter 15
Welding: Principles and Practices, Chapter 19

INTRODUCTORY STATEMENT

Silver soldering or silver brazing is really a form of low temperature brazing. When properly done, it is stronger than a lead soldered joint and, in some instances, stronger than a weld joint. In some cases, this procedure is preferred because it does not affect the heat temperature of the original metals as welding does. This is a very important industrial process.

Presentation Outline	Activities
I. Safety Equipment II. Oxyacetylene Welding Outfit III. Materials A. Steel, stainless steel or copper (1/16" x 1" x 4") B. Handy flux C. Wire (#50 Ancosil, 1/16" diameter) D. Welding tip (No. 3) IV. Procedure	1. Prepare strip to be brazed or soldered by thoroughly cleaning and removing all burrs. Strips should be straight. Remove all surface oxides. 2. Apply a thin layer of flux to one side of the strips and place them together. 3. Lap the ends in and make sure they are in close contact. The ideal space for the brazed joint is about .0015.

4. Apply 22 flame to work piece, manipulating the torch for even heat on the general area. Do not apply flame directly to brazing rod.
5. Use the flux as a guide to determine the right temperature. When the work is hot enough, apply the rod to the work. The heat will cause the rod to melt and flow into the desired area by capillary action.
   NOTE: The flux will dry and turn white when heat is first applied. As it gets hotter, it melts forming clear beads at first. With more heat, it will flow evenly around the joint. If temperature is raised further, the flux will separate or crawl and leave dry areas with a resulting poor bond and surface appearance.
6. Test the joint by attempting to peel the weld apart. If properly made, the metal will tend to tear before the bond breaks.
7. Cool and clear flux from work piece.
   NOTE: Tubing joints, lap joints, and butt joints can be done using the same procedure.

REVIEW POINTS

1. A brazed joint is stronger than a soldered joint and is in some instances stronger than a welded joint. (True or false)
2. Brazing is a relatively new process, that is, it came into use only a few years ago. (True or false)
3. A neutral flame usually gives the best results in this process. (True or false)
4. The smaller the silver brazing filler metal thickness, the stronger the joint. (True or false)

SHIELDED METAL ARC WELDING

Shielded Metal Arc Welding
Lesson Plan 1

Suggested instructional time
6 class periods

SETTING UP EQUIPMENT

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to set up metal arc welding equipment following the correct procedure and describe safety precautions with 100% accuracy.

CRITERION - REFERENCE MEASURE

The student will name the types of metal arc welding machines and identify the major metal arch welding equipment. The student will demonstrate and describe the safety precautions to follow and the correct procedure to use in setting up metal arc welding equipment.

REFERENCES

Modern Welding, Chapters 6 and 8
Welding Technology, Chapter 13
Welding: Principles and Practices, Chapter 6
"Introduction to Electric Welding" (film and cassette)
"Electric Welding Safety and Set Up" (film and cassette)

INTRODUCTORY STATEMENT

Of all the welding processes used, shielded metal arc or stick electrode is the most common. It uses either an AC or DC current to produce an arc between the electrode and the workpiece. Metal arc welding is a relatively inexpensive method of joining metals.

Presentation Outline	Activities
I. Metal Arc Welding Equipment II. Type of Metal Arc Welders III. Set Up Procedure	1. Identify the types of metal arc welding machines. 2. Identify the metal arc welding equipment. 3. Describe the safety precautions to observe in setting up metal arc welding equipment.

4. Demonstrate the proper procedure to follow in setting up metal arc welding equipment.

REVIEW POINTS

1. Name the types of metal arc welding machines.
2. Identify the major metal arc welding equipment.
3. Describe the safety precautions to follow in setting up metal arc welding equipment.
4. Explain the correct procedure to follow in setting up metal arc welding equipment.

Shielded Metal Arc Welding
Lesson Plan 2

Suggested instructional time
9 class periods

ELECTRODE IDENTIFICATION AND CHARACTERISTICS

OBJECTIVE

Given a weld or position, the student will be able to select the correct electrode for that type of weld or position with 100% accuracy.

CRITERION - REFERENCE MEASURE

The student will explain the classification system of electrodes, the proper procedure for the care and storage of rods, and the relationship of the size of the electrode to the thickness of the metal to be welded.

REFERENCES

Modern Welding, Chapter 6
Welding Technology, Chapter 15
Welding: Principles and Practices, Chapter 7

INTRODUCTORY STATEMENT

The electrode is used to deposit a filler metal between the base metals. There are many types of electrodes for different applicators.

Presentation Outline	Activities
I. Classification	1. Class discussion on electrodes.
II. Care and Storage	2. Identify rod sizes.
III. Relationship of Size of the Electrode to Thickness of Metal to be Welded	3. Identify types of electrodes.
IV. Current Ranges	4. Amp ranges for electrodes.
	5. Polarity for electrodes.

REVIEW POINTS

1. Give the rod size, current range, and polarity to use for each of the rods studied.
2. Given the size and types of base metal, which can be used for each rod?
3. Write a paragraph on "How Electrodes Are Stored and Why."

Shielded Metal Arc Welding
Lesson Plan 3

Suggested instructional time
3 class periods

CARRYING AN ARC

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to create an arc using the correct procedures as demonstrated by the instructor. The procedure must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the tapping, the scratching method, and the procedure for establishing the arc length.

REFERENCES

Modern Welding, Chapter 5
Welding Technology, Chapter 14
Welding: Principles and Practices, Chapter 20
"Electric Arc Welding and Cutting" (film and cassette)

INTRODUCTORY STATEMENT

Creating an arc is one of the first tasks in learning to weld. The two basic ways of striking an arc are tapping and scratching.

Presentation Outline	Activities
I. Method of Striking an Arc II. Establish Arc Length	1. Select proper base metal and prepare. 2. Select proper electrode for base metal. 3. Select correct current (high or low). 4. Make cable connections. 5. Wear proper safety clothing. 6. Start machine. 7. Insert electrode. 8. Strike an arc by either tapping or scratching.

REVIEW POINTS

1. What is the tapping method?
2. What is the scratching method?
3. What is the procedure for establishing the arc length?
4. What is the best method for carrying an arc?

Shielded Metal Arc Welding
Lesson Plan 4

Suggested instructional time
6 class periods

MAKING A PAD OF BEADS IN THE FLAT POSITION PROGRESSING TO HORIZONTAL POSITION

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to run a pad of beads beginning with the work piece in the flat position and running the beads from left to right and from right to left, advancing to work piece to a true vertical position. Pad must be graded acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate running beads in the flat position from left to right and right to left, the proper overlap of each weld bead to form a uniform pad, the first step of advancing the work piece to a vertical position, and the correct electrode angle while the work piece is flat and as the angle increases.

REFERENCES

Modern Welding, Chapter 5
Welding Technology, Chapter 14
Welding: Principles and Practices, Chapter 20
"Electric Arc Welding and Cutting" (film and cassette)

INTRODUCTORY STATEMENT

Using the approach to running beads in all positions from flat to vertical on one work piece saves hard-to-get metals. The student goes from a flat to horizontal weld on a flat surface in eight steps or upward advances of the plate.

Presentation Outline	Activities
I. Personal Safety Equipment II. Running Beads	1. Attach 1/2" x 6" x 6" steel plate to suitable jig or fixture in the flat position. 2. Stand squarely in front of work piece. 3. Begin on left side, strike the arc, and proceed to the right side of the work piece.

4. Clean the weld thoroughly.
5. Strike the arc on the right side of the plate and position the rod 5° or 10° in the direction of travel with no side angle. The center of the puddle should be exactly at the edge of the preceding bead for each pass.
6. Continue this procedure to the opposite side of the work piece. If beads are uniform and straight with proper overlap 1/3, turn the work piece one quarter turn and raise the back side 1" and secure. Begin again at the nearest side.
7. Repeat procedure with proper arc length, speed of travel, angle of electrode, and current setting.
8. As the angle of the work piece increases to the vertical position, adjust electrode angle to keep electrode in right relationship with angle of work piece.
9. Continue until work piece is inclined to the true 90° angle.

REVIEW POINTS

Work piece must have straight beads with smooth even ripples and a uniform surface with little or no grooves between the weld beads.

Shielded Metal Arc Welding
Lesson Plan 5

Suggested instructional time
6 class periods

MAKING A PAD OF BEADS IN THE FLAT POSITION PROGRESSING TO VERTICAL POSITION

OBJECTIVE

Given necessary equipment and instruction, the student will be able to run a pad of beads in the vertical position, beginning with the work piece in the flat position and progressing to the 90° vertical position. Pad must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstate running beads in the flat position from front to back only and the correct electrode angle for the pad of beads. The student will explain the procedure and demonstrate the correct travel speed, arc length, and bead overlap.

REFERENCES

Modern Welding, Chapter 18
Welding: Principles and Practices, Chapter 21

INTRODUCTORY STATEMENT

Vertical welds are most important in all manual welding processes. This work piece also saves time and metal and the training is complete at all angles from flat to vertical.

Presentation Outline	Activities
I. Personal Safety Equipment II. Equipment III. Materials A. Mild steel plate (1/2" x 6" x 6") B. Electrodes (E6010, E6011, E6013, E7018)	1. Attach 1/2" x 6" x 6" plate to suitable jig or fixture in the flat position. 2. Stand squarely in front of the work piece. 3. Strike the arc on the front left side of the plate. Then, incline the electrode 10° to 15° in the direction of travel with no side angle and proceed to weld from front to back.

4. Return to the front side of the plate and strike the arc at the edge of the first bead and proceed again to the back of the work piece.
5. Continue until plate is crossed.
6. If beads are uniform and have the proper overlap, elevate the back of the work piece 1".
7. After work piece has been elevated to more than a 45° angle, the welder will assume a 5° to 10° push position of the electrode with no side angle.
8. Continue until a 90° vertical angle is achieved.

REVIEW POINTS

Work piece must have straight beads with smooth even ripples and a uniform surface with little or no grooves between the weld beads.

Shielded Metal Arc Welding
Lesson Plan 6

Suggested instructional time
6 class periods

TEE-FILLET JOINT HORIZONTAL POSITION

OBJECTIVE

Given necessary equipment and instruction, the student will be able to make a single pass tee-fillet weld on 3/8" mild steel plate in the horizontal position. The weld must be graded acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate setting up the tee-fillet joint and the tee-fillet weld in the horizontal position.

REFERENCES

Basic Arc Welding, Unit 19
Modern Welding, Chapter 18
Welding: Principles and Practices, Chapter 21

INTRODUCTORY STATEMENT

Tee-fillet joints are one of the main joints in metal fabrication. This lesson deals with welding the tee-fillet joint in the horizontal position.

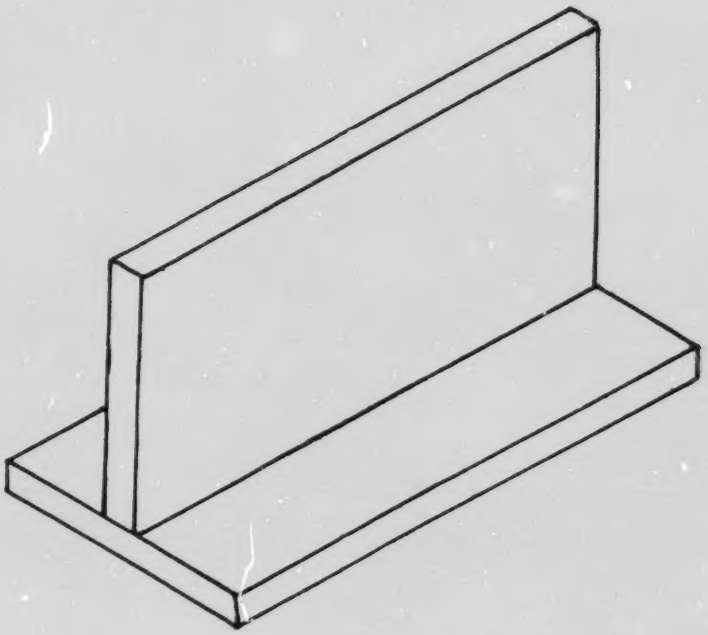
Presentation Outline	Activities
I. Personal Safety Equipment II. Equipment III. Materials A. Mild steel plate (3/8" x 2" x 7") B. Electrodes (E6010, E6011, E6013, E7018)	1. Secure the plate in the tee-fillet position with tacks. 2. Place flat on welding table. 3. Strike the arc at the left end on the side opposite the tacks. Angle the electrode (45°) from the horizontal (5° or 10°) in the direction of travel. Proceed to the opposite end. 4. Cool the work piece in water and weld the tack side in the same manner. The second bead should nearly cover the first one of the three-bead fillet.

5. To add a second and third bead for a multipass weld, center the electrode over the bottom edge of the first bead at approximately a 70° angle from horizontal. Incline electrode 5° or 10° in direction of travel and continue to opposite end.
6. To add the third to the joint, cool the work piece and clear the slag. Center the electrode over the top edge of the second pass and angle the electrode 30° from the horizontal and 5° or 10° in direction of travel.

REVIEW POINTS

Work piece must have straight beads with uniform ripples, a smooth even edge with no undercut at either horizontal or vertical leg, and both legs must be approximately the same length.

100



TEE-FILLET JOINT
HORIZONTAL POSITION

Shielded Metal Arc Welding
Lesson Plan 7

Suggested instructional time
6 class periods

TEE-FILLET JOINT - VERTICAL POSITION

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld a tee-fillet joint in the vertical position with a three-stringer bead, multipass weld. The weld must be graded acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate setting up a tee-fillet joint and making the fillet weld in the vertical position.

REFERENCES

Basic Arc Welding
Welding: Principles and Practices, Chapter 21
Hobart Training Workbook, Section SMAWA Topic 7, p. 17
Modern Welding, Chapter 18

INTRODUCTORY STATEMENT

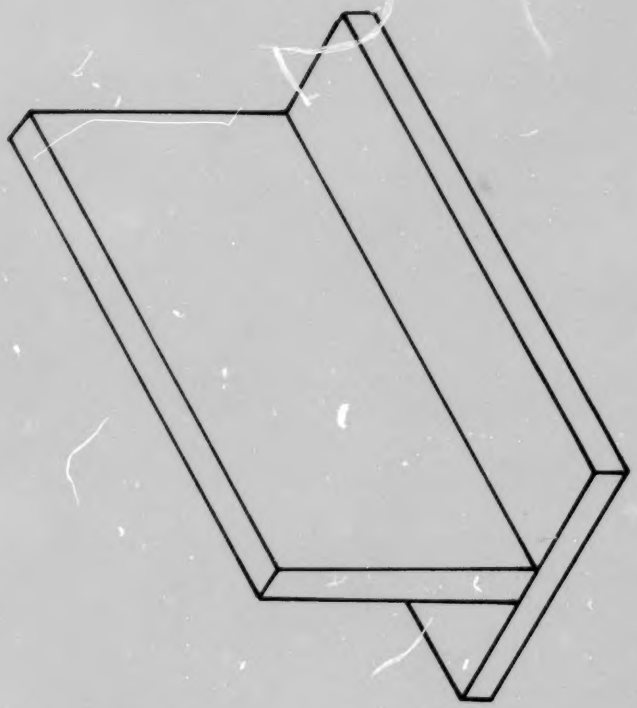
Tee-fillet joints are one of the main joints in metal fabrication. This lesson deals with welding the tee-fillet joint in a vertical position.

Presentation Outline	Activities
I. Personal Equipment II. Equipment III. Materials A. Mild steel plate (3/8" x 2" x 7") B. Electrodes (E6010, E6011, E6013, E7018)	1. Secure the plate in the tee-fillet position with tacks. 2. Tack weld at a suitable height in the vertical position. 3. Position the electrode at 45° from the vertical leg and make the first stringer bead. Demonstrate the correct electrode manipulation for the particular electrode specified.

4. For the second bead, center the electrode at the right edge of the first bead and run another stringer bead vertically covering about half of the first pass.
5. For the third and final bead, center the electrode over left edge of the second bead and proceed from bottom to top.
6. The work piece should be cooled in water after each pass.

REVIEW POINTS

The beads should be straight and uniform in size, smooth even ripples with all three beads forming a multipass weld joint with a slight contour, and no under cut at the toes of either edge.



TEE-FILLET
VERTICLE POSITION

Shielded Metal Arc Welding
Lesson Plan 8

Suggested instructional time
6 class periods

TEE-FILLET - OVERHEAD POSITION

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to make a three-bead fillet weld in the overhead position. Weld must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate setting up the tee-fillet joint and welding the tee joint in the overhead position with three stringer beads.

REFERENCES

Basic Arc Welding
Modern Welding, Chapter 18
Welding Training Workbook
Welding: Principles and Practices, Chapter 21

INTRODUCTORY STATEMENT

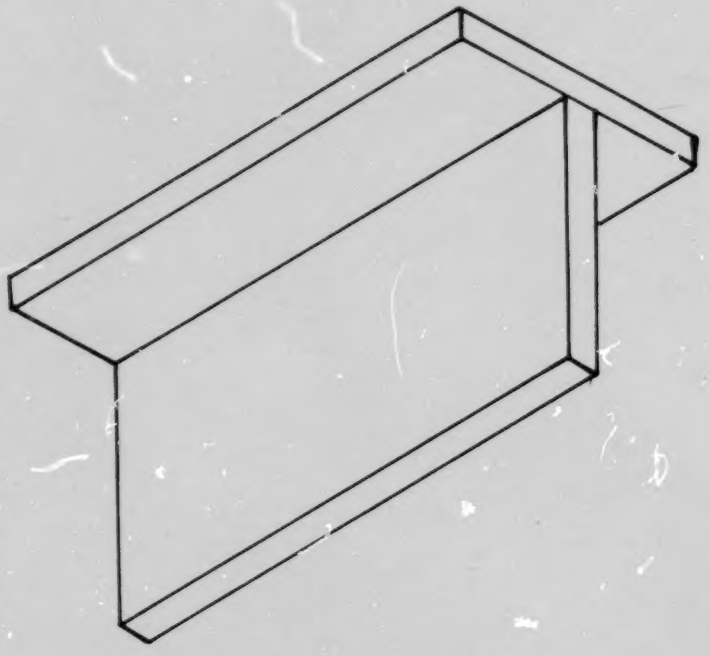
Tee-fillet joints are one of the main joints in metal fabrication. In this lesson the student will learn to weld a tee-fillet joint in an overhead position. Welds should be made with at least two different electrodes, E6010 or E6011 and E7018.

Presentation Outline	Activities
I. Personal Safety Equipment II. Equipment III. Materials A. Mild steel plate (3/8" x 2" x 7") B. Electrodes, (E6010, E6011, E6013, E7018)	1. Secure the plate in the tee-fillet position with tacks. 2. Tack weld to a jig or fixture at eye level or slightly above. 3. Position the electrode at the left edge of the joint (45° from the vertical leg) and incline electrode about 5° to 10° in direction of travel.

4. Strike the arc and make the first stringer bead with equal amount of weld on each leg vertically and horizontally.
5. For the second pass, center the electrode at the bottom edge of the first bead and incline 5° to 10° in the direction of travel and 30° from the vertical leg.
6. For the third and final bead, center the electrode at the top edge of the second bead, incline 5° to 10° in direction of travel and 30° from the vertical leg.

REVIEW POINTS

Welds beads should be straight and uniform in size. Smooth, even ripples and the three beads should form a slight contour with no under cut at the toes of either edge.



TEE-FILLET
OVERHEAD POSITION

Shielded Metal Arc Welding
Lesson Plan 9

Suggested instructional time
6 class periods

BUTT, LAP, TEE-FILLET, AND CORNER WELDS IN THE FLAT POSITION ON LIGHT GAUGE METAL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to perform butt, lap, tee-fillet, and corner welds in the flat position. Welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt, lap, tee-fillet and corner welds in the flat position.

REFERENCES

Modern Welding, Chapter 5
Welding Technology, Chapter 14
Welding: Principles and Practices, Chapter 20

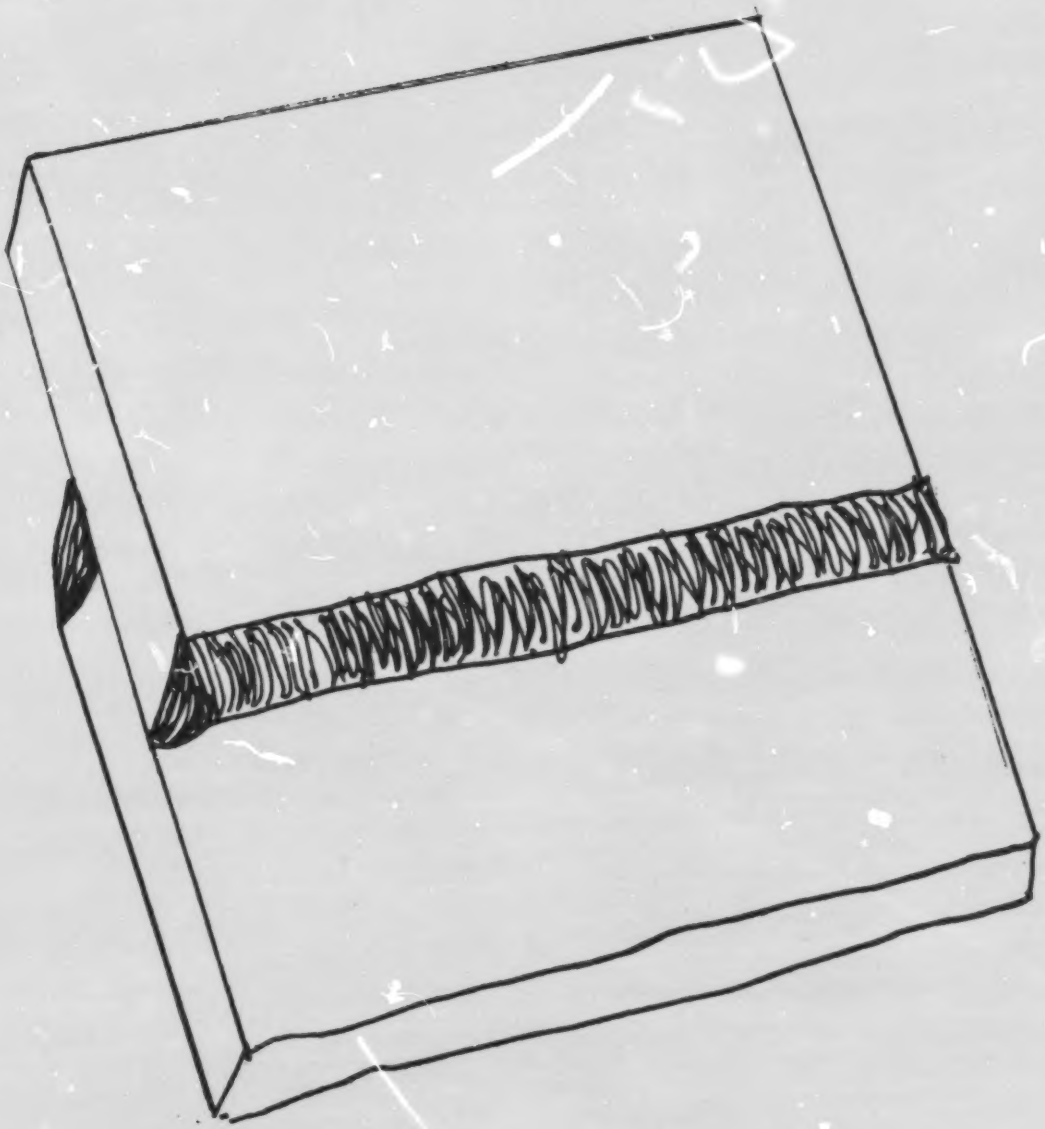
INTRODUCTORY STATEMENT

Flat position welding has many applications in industry. In this lesson, the student will make butt, lap, tee-fillet, and corner welds in the flat position.

Presentation Outline	Activities
I. Procedure II. Electrode Manipulation	1. Select and prepare materials. 2. Tack the work pieces. 3. Weld each of the joints in the flat position. See following drawing.

REVIEW POINTS

Weld beads should be straight and uniform in size with smooth even ripples.



FLAT POSITION

Shielded Metal Arc Welding
Lesson Plan 10

Suggested instructional time
6 class periods

BUTT, LAP, TEE-FILLET, AND CORNER WELDS IN THE HORIZONTAL POSITION ON LIGHT GAUGE METAL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to perform butt, lap, tee-fillet, and corner welds in the horizontal position. Welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt, lap, tee-fillet, and corner welds in the horizontal position.

REFERENCES

Modern Welding, Chapter 5
Welding Technology, Chapter 14
Welding: Principles and Practices, Chapter 20

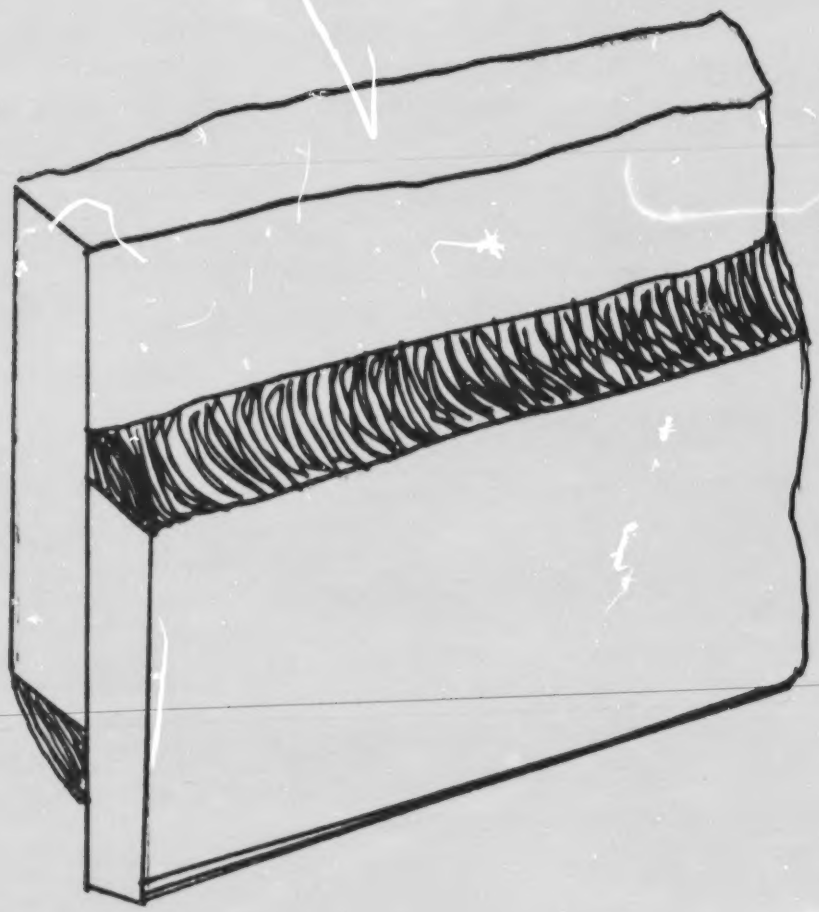
INTRODUCTORY STATEMENT

Horizontal position welding has many applications in industry. In this lesson, the student will make butt, lap, tee-fillet, and corner welds in the horizontal position.

Presentation Outline	Activities
I. Procedure II. Electrode Manipulation	1. Select and prepare materials. 2. Tack the work pieces. 3. Weld each of the joints in the horizontal position. See following drawing.

REVIEW POINTS

Weld beads should be straight and uniform in size with smooth even ripples.



HORIZONTAL POSITION

Shielded Metal Arc Welding
Lesson Plan 11

Suggested instructional time
6 class periods

BUTT, LAP, TEE-FILLET, AND CORNER WELDS IN THE VERTICAL POSITION ON LIGHT GAUGE METAL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to perform butt, lap, tee-fillet, and corner welds in the vertical position. Welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt, lap, tee-fillet, and corner welds in the vertical position.

REFERENCES

Modern Welding, Chapter 5
Welding Technology, Chapter 14
Welding: Principles and Practices, Chapter 20

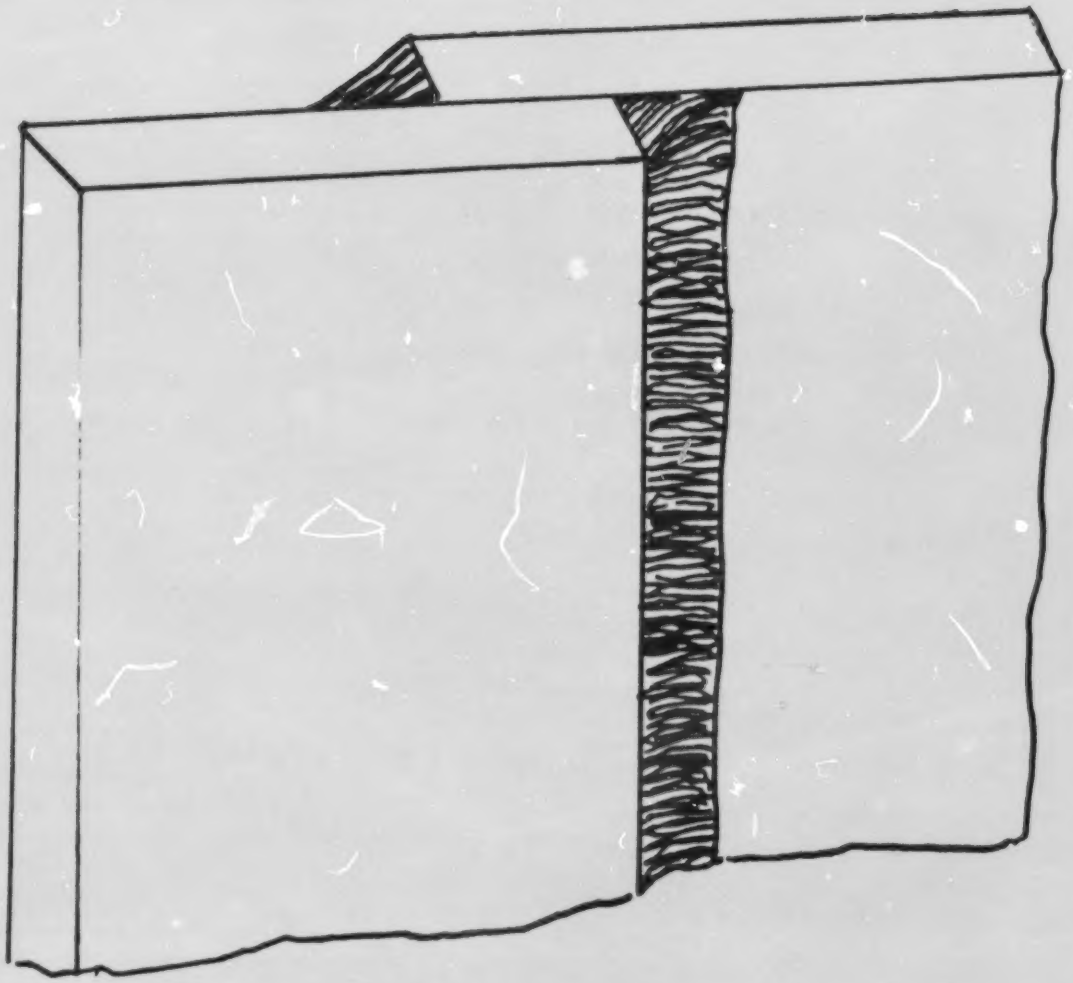
INTRODUCTORY STATEMENT

Vertical position welding has many applications in industry. In this lesson, the student will make butt, lap, tee-fillet, and corner welds in the vertical position.

Presentation Outline	Activities
I. Procedure II. Electrode Manipulation	1. Select and prepare materials. 2. Tack the work pieces. 3. Weld each of the joints in the vertical position. See following drawing.

REVIEW POINTS

Weld beads should be straight and uniform in size with smooth even ripples.



VERTICAL POSITION

Shielded Metal Arc Welding
Lesson Plan 12

Suggested instructional time
6 class periods

BUTT, LAP, TEE-FILLET, AND CORNER WELDS IN THE OVERHEAD POSITION ON LIGHT GAUGE METAL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to perform butt, lap, tee-fillet, and corner welds in the overhead position. Welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt, lap, tee-fillet, and corner welds in the overhead position.

REFERENCES

Modern Welding, Chapter 5
Welding Technology, Chapter 14
Welding: Principles and Practices, Chapter 20

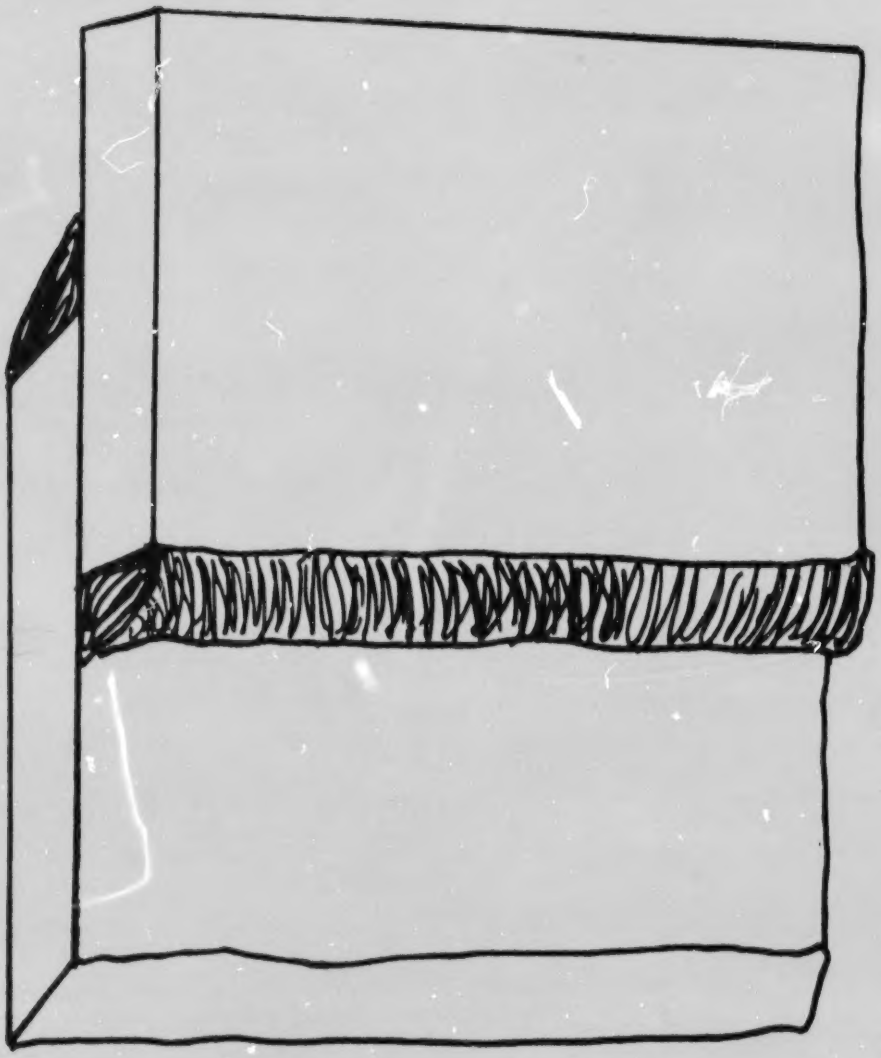
INTRODUCTORY STATEMENT

Overhead position welding has many applications in industry. In this lesson, the student will make butt, lap, tee-fillet, and corner welds in the overhead position.

Presentation Outline	Activities
I. Procedure II. Electrode Manipulation	1. Select and prepare materials. 2. Tack the work pieces. 3. Weld each of the joints in the overhead position. See following drawing.

REVIEW POINTS

Welds beads should be straight and uniform in size with smooth even ripples.



OVERHEAD POSITION

RECOMMENDED FOR

ADVANCED SHIELDED METAL ARC WELDING

Shielded Metal Arc Welding
Lesson Plan 13

Suggested instructional time
20 class periods

BEVELED BUTT JOINTS WITH BACKING STRIPS IN THE FLAT, HORIZONTAL VERTICAL, AND OVERHEAD POSITIONS ON HEAVY PLATE

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to perform beveled butt joint welds with backing strips in the flat, horizontal, vertical, and overhead positions. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the beveled butt joint with backing strip in the flat, horizontal, vertical, and overhead positions.

REFERENCES

Modern Welding, Chapter 5
Welding Technology, Chapter 14
Welding: Principles and Practices, Chapter 21

INTRODUCTORY STATEMENT

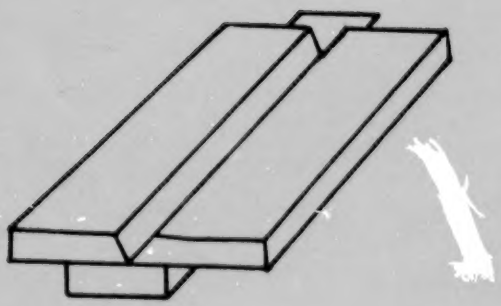
The beveled butt joint construction is used frequently in piping, pressure vessels, and shipyard construction. The backing material creates the effect of welding a joint with a chill ring. This type of weld is identical to the test specified by code authorities, such as the Bureau of Shipping, the Department of the Navy, and the American Welding Society. The root opening varies with different welding shops.

Presentation Outline	Activities
I. Procedure II. Electrode Manipulation A. Arc length B. Speed of travel C. Angle of electrode D. Current setting	1. Select and prepare the plates. 2. Tack the plates and backing strip. 3. Weld the beveled butt joint with backing strip. See following drawing. a) flat position b) horizontal c) vertical position d) overhead position

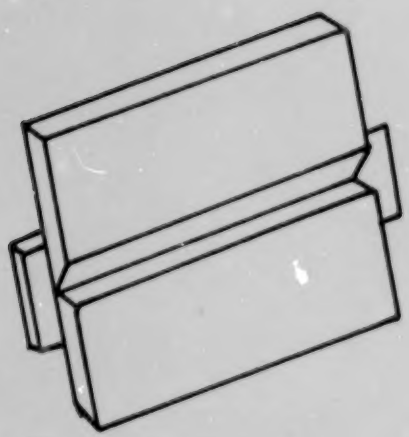
REVIEW POINTS

1. Complete the beveled butt joint weld with backing strips in the flat, horizontal, vertical, and overhead positions.
2. Each weld must be tested by at least one of the following procedures.
   a) visual inspection
   b) X-ray
   c) tensile test
   d) face and root bend test

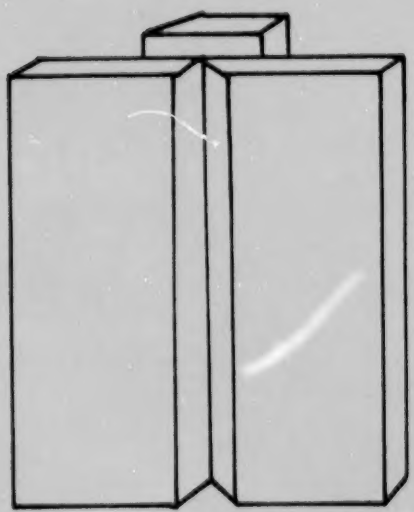
BEVELED BUTT JOINTS WITH BACK STRIPS



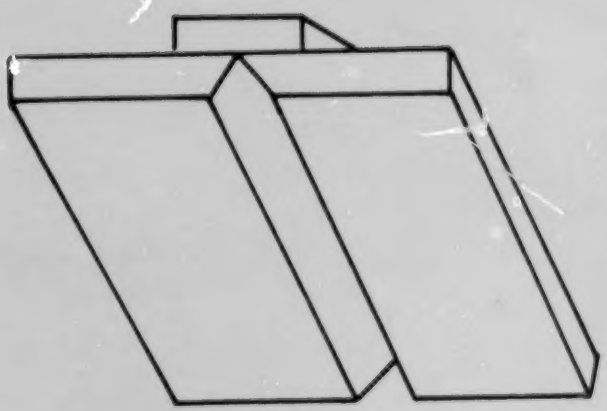
FLAT



HORIZONTAL



VERTICAL



OVERHEAD

Shielded Metal Arc Welding
Lesson Plan 14

Suggested instructional time
60 class periods

SINGLE VEE-GROOVE WELD, OPEN BUTT JOINT IN FLAT, HORIZONTAL, VERTICAL, AND OVERHEAD POSITIONS

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform single vee-groove welds in the flat, horizontal, vertical, and overhead positions. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the single vee-groove weld in the flat, horizontal, vertical, and overhead position.

REFERENCES

Modern Welding, Chapter 5
Welding Technology, Chapter 14
Welding: Principles and Practices, Chapter 21

INTRODUCTORY STATEMENT

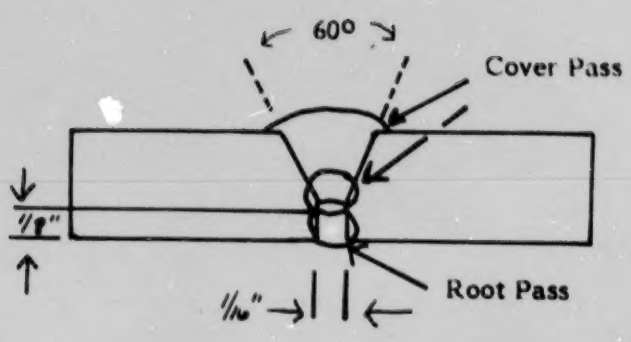
Single vee-groove open butt welding has many applications in industry. This type of weld is identical to the test specified by code authorities such as the Bureau of Shipping, the Department of the Navy, the American Welding Society, and the Nuclear Regulatory Commission.

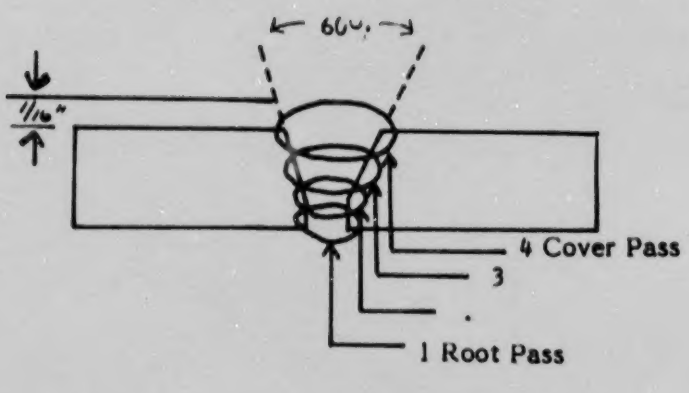
Presentation Outline	Activities
I. Procedure	1. Select and prepare materials.
II. Electrode Manipulation	2. Tack the workpiece.
A. Arc length	3. Deposit the root bead.
B. Speed of travel	4. Deposit the filler beads.
C. Angle of electrode	5. Deposit the cover bead. See following drawing.
D. Current setting	

REVIEW POINTS

1. Complete the procedure for making a single vee-groove weld, open butt joint in the flat, horizontal, vertical, and overhead positions.
2. All welds must be given the bend test to determine if the weld is acceptable.

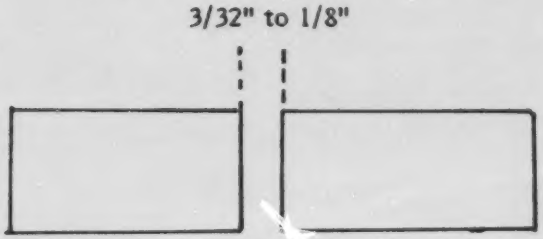
SEQUENCE OF PASSES IN A MULTIPLE PASS BUTT JOINT





TYPES OF BUTT JOINTS

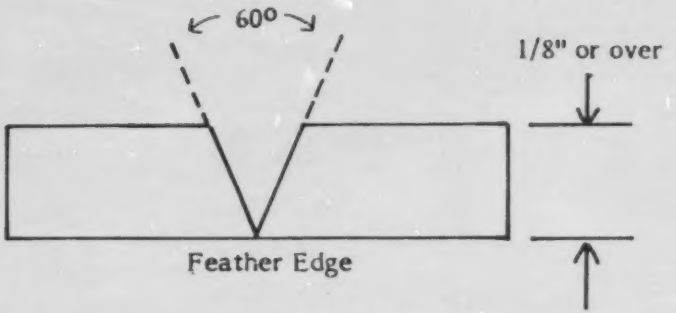
Closed Joint



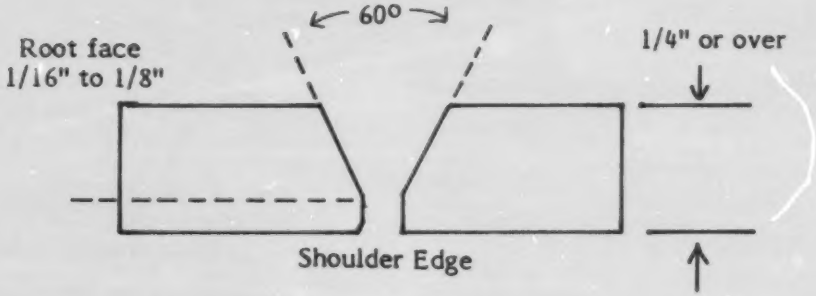
Open Joint

V-Joint

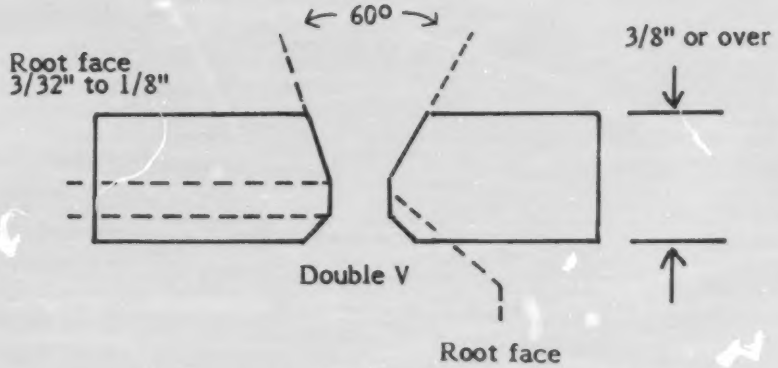
PREPARING A V-JOINT



Feather Edge



Shoulder Edge



Double V

Root face

Shielded Metal Arc (Pipe)
Lesson Plan 15

Suggested instructional time
30 class periods

BUTT JOINT VEE-GROOVE HORIZONTAL POSITION, ROLLED

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld a vee-groove butt joint in the horizontal position while the pipe is being rolled. The weld must meet code specifications for certified welding.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the vee-groove butt joint while the pipe is being rolled in the horizontal position.

REFERENCES

Welding Technology, Chapter 23
Welding: Principles and Practices, Chapter 23

INTRODUCTORY STATEMENT

Pipe is in a fixed position most of the time. Occasionally it can be turned or rolled which permits the weldor to have better control over the weld. This lesson addresses the procedures and techniques needed to accomplish a sound weld in this position.

Presentation Outline	Activities
I. Preparation A. Material selection 1. mild steel pipe (3/8" to 1/2" thick, 3" to 8" in diameter) 2. flamecut or machine 3. electrode (E6010, 1/8" diameter) B. Current adjustment C. Cable connections D. Protective clothing	1. Mount the pipe in a jig so that the axis is horizontal and the weld joint is vertical. 2. Demonstrate how to run the first and second bead and the placement of the beads. 3. Have the students practice welding in this position.

II. Procedure
   A. Start machine
   B. Insert electrode in holder
   C. Strike arc
   D. Weld joint--multiple pass
   E. Clean and inspect

REVIEW POINTS

1. Complete the vee-groove butt joint in the horizontal position while the pipe is being rolled.
2. The weld must be tested by at least one of the following procedures.
   a) visual inspected
   b) X-ray
   c) tensil test
   d) bend test

123

Shielded Metal Arc Welding (Pipe)
Lesson Plan 16

Suggested instructional time
45 class periods

BUTT JOINT VEE-GROOVE HORIZONTAL POSITION, FIXED

OBJECTIVE

Given necessary equipment and instruction, the student will be able to weld a vee-groove butt joint in the horizontal position while the pipe is fixed. The weld must meet code specifications for certified welding.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the vee-groove butt joint while the pipe is fixed in the horizontal position.

REFERENCES

Welding: Principles and Practices, Chapter 23
Modern Welding, Chapter 27
Welding Technology, Chapter 23

INTRODUCTORY STATEMENT

One of the most common types of joints in welding pipe is the vee-groove. This lesson addresses the procedures and techniques required to accomplish a sound weld when welded in the horizontal position.

Presentation Outline	Activities
I. Preparation A. Material selection 1. Mild steel pipe (3/8" to 1/2" thick, 3" to 8" in diameter) 2. flamecut or machine 3. electrode (E6010, 1/8" diameter) B. Current adjustment C. Cable connections D. Protective clothing II. Procedure A. Start machine B. Insert electrode in holder C. Strike arc	1. Mount the pipe in a suitable place either in the booth, in a jig on the floor, or in a corner. 2. Demonstrate the technique of getting into position to weld and run a bead. 3. Have the students practice getting into positon and running beads.

D. Weld joint--multiple pass
E. Clean and inspect

REVIEW POINTS

1. Complete the vee-groove butt joint weld in the horizontal position while the pipe is fixed.
2. The weld must be tested by at least one of the following procedures.
   a) visually inspected
   b) X-ray
   c) tensil test
   d) bend test

123

Shielded Metal Arc (Pipe)
Lesson Plan 17

Suggested instructional time
60 class periods

BUTT JOINT VEE-GROOVE VERTICAL POSITION, FIXED

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld a vee-groove butt joint in the vertical position while the pipe is fixed. The weld must meet code specifications for certified welding.

CRITERION - REFERENCE MEASURE

Modern Welding, Chapter 27
Welding Technology, Chapter 23
Welding: Principles and Practices, Chapter 23

INTRODUCTORY STATEMENT

One of the seemingly more difficult welds to make is the vertical vee-groove weld in pipe in the fixed position. The lesson addresses the procedures and techniques required in order to reduce the margin of difficulty in making this weld.

Presentation Outline	Activities
I. Preparation A. Material selection 1. mild steel pipe (3/8" to 1/2" thick, 3" to 8" in diameter) 2. flamecut or machine 3. electrode (E6010, 1/8" diameter) II. Procedure A. Start machine B. Insert electrode in holder C. Weld joint--multiple pass E. Clean and inspect	1. Mount the pipe in a jig so that its axis is horizontal and weld joint is vertical. 2. Demonstrate how to run the first and second bead and the placement of the beads. 3. Have the students practice welding in this position.

REVIEW POINTS

1. Complete the vee-groove butt joint in the vertical position while the pipe is fixed.
2. The weld must be tested by at least one of the following procedures.
   a) visually inspected
   b) X-ray
   c) tensil test
   d) bend test

Shielded Metal Arc (Pipe)
Lesson Plan 18

Suggested instructional time
75 class periods

BUTT JOINT VEE-GROOVE 45° POSITION, FIXED (ARKANSAS BELL HOLE)

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to weld a vee-groove butt joint in the 45° position while the pipe is fixed. The weld must meet code specifications for certified welding.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the vee-groove butt joint while the pipe is fixed in the 45° position.

REFERENCES

Modern Welding, p. 694

INTRODUCTORY STATEMENT

One of the more difficult welds to make is the 45° vee-groove weld in pipe in the fixed position. This lesson addresses the procedures and techniques required in order to reduce the margin of difficulty in making this weld.

Presentation Outline	Activities
I. Preparation A. Material selection 1. mild steel pipe (3/8" to 1/2" thick, 3" to 8" in diameter) 2. flamecut or machine 3. electrode (E6010, 1/8" diameter) B. Current adjustment C. Cable connections D. Protective clothing II. Procedures A. Start machine B. Insert electrode in holder C. Strike arc	1. Mount the pipe in a jig so that its axis is horizontal and weld joint is at a 45° angle. 2. Demonstrate how to run the first and second bead and the placement of the beads. 3. Have the students practice welding in this position.

D. Weld joint—multiple pass
E. Clean and inspect

REVIEW POINTS

1. Complete the vee-groove butt joint in the 45° position while the pipe is fixed.
2. The weld must be tested by at least one of the following procedures.
   a) visually inspected
   b) X-ray
   c) tensil test
   d) bend test

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TIG WELDING

TIG Welding
Lesson Plan 1

Suggested instructional time
6 class periods

THE TIG WELDING PROCESS

OBJECTIVE

Given a list of five basic characteristics, the student will be able to identify and describe at least four of the characteristics of the TIG welding process with 95% accuracy.

CRITERION - REFERENCE MEASURE

The student will explain the basic principle of operation for TIG welding and describe the advantages of TIG welding over other processes. The student will describe the procedure used when making TIG welds.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 18
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Because of its versatility and quality of welds produced, the TIG welding process has grown faster in popularity than many of the processes in use today.

Presentation Outline	Activities
I. Generally-Used Terms A. Tungsten-electrode B. Inert gas C. Nozzles D. Gas-blanket E. Arc F. Flow meter G. Power supply H. Filler metal II. General Applications A. Thickness of metals	1. Demonstrate TIG weld in lab.

B. Advantages
C. Disadvantages
D. Cost and quality
E. Automatic applications

REVIEW POINTS

1. List five advantages of TIG welding over other welding processes.
2. List five types of metals that can readily be welded with the TIG process.

TIG Welding
Lesson Plan 2

Suggested instructional time
9 class periods

TIG WELDING EQUIPMENT AND SUPPLIES

OBJECTIVE

Given instruction in how to set up TIG equipment, the student will be able to set up the TIG equipment following the correct procedures and describe the safety precautions with 95% accuracy.

CRITERION - REFERENCE MEASURE

The student will: (1) describe the two polarities of DC current and list advantages and disadvantages of each; (2) describe the TIG welding process using AC current and explain the use of high frequency; (3) describe the characteristics of gases used in TIG welding as to their advantages, disadvantages, selection, and application; (4) describe the electrode used in TIG welding and give applications and advantages of each; (5) identify various filler metals and cite their applications; and (6) cite safety precautions that should be taken before, during, and after performing TIG welds.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 18
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Because TIG welding is a complex process, the selection of proper equipment, supplies, and machine settings can be a critical factor in the outcome of the weld being produced.

Presentation Outline	Activities
I. Factors Governing Equipment Selection A. Material to be welded B. Number and rate of welds to be made C. Location and position of welds D. Joint design II. Major Components of a TIG Outfit A. Power source B. Torch C. Electrodes	1. Demonstrate the procedure in setting up the TIG equipment. 2. Explain the safety precautions. 3. Have students select proper settings and supplies for various weld assignments.

D. Shielded gas
E. Filler metals

III. Optional Equipment
A. Leads and welding cables
B. Water supply for cooling
C. Oscillators
D. Foot controls
E. Traversing mechanism

REVIEW POINTS

1. Describe the necessary characteristics of a power supply unit for TIG welding.
2. Explain the use of high frequency in TIG welding.
3. List the three polarities and their abbreviations. Describe each of their characteristics as applied to TIG welding.

TIG Welding
Lesson Plan 3

Suggested instructional time
12 class periods

PREPARING TO WELD

OBJECTIVE

Given necessary equipment and instruction, the student will be able to set up and adjust equipment according to specifications for establishing an arc and carrying a puddle. The procedure for setting up the equipment must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment, setup, and test procedure for TIG equipment and accessories. The student will explain and demonstrate proper selection of current and gas flow for weld assignments.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 19
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Because TIG welding is a complex welding process, proper procedure must be used in preparing for all welds regardless of size or else acceptable results will not be obtained.

Presentation Outline	Activities
Equipment and Accessories I. Welding Machine II. High Frequency III. TIG Torch IV. Electrodes, Collets, and Gas Nozzles V. Gas Cylinder VI. Flow Meter VII. Water Supply (If required)	1. Select required tools and materials. 2. Clean and prepare work table. 3. Assemble and inspect TIG equipment. a) Check gas supply lines for leads.

VIII. Weldor Protective Equipment
IX. Work Table
X. Stainless Steel Wire Brush
XI. Pliers
XII. Filler Rod

b) Select proper nozzle and electrodes.
c) Check all leads.

4. Open gas cylinder valve and adjust for proper flow.
5. Check water supply if W.C. torch is being used.
6. Set current range for weld to be made.
7. Switch on welder.
8. Put on helmet, gloves, and protective clothing as required.
9. Establish and carry a molten puddle on these settings.
10. Shut down equipment.
11. Repeat the above for different assignments.

REVIEW POINTS

1. Describe the complete set up and test procedure for a TIG welding outfit.
2. Describe the selection of electrode type, current, gas, and gas flow for welding:
   a) aluminum
   b) on carbon steel
   c) stainless steel

TIG Welding
Lesson Plan 4

Suggested instructional time
12 class periods

FLAT POSITION WELDING ON MILD STEEL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to perform flat position butt, lap, tee, and outside corner welds on mild steel. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for flat position welding on mild steel. The student will explain and demonstrate proper selection of control settings, filler wire and welding procedure for flat position butt welds, lap welds, tee welds, and outside corner welds on mild steel.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 20
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Because welds made in the flat position tend to be stronger and more easily performed, it is usually advantageous for the weldor to try to position as much of the welding as possible in the flat position.

Presentation Outline	Activities
I. Equipment and Accessories	1. Select equipment and accessories.
II. Flat Welds	2. Set up and adjust for flat position welds on .080" mild steel.
III. Demonstrate Procedures	3. Perform butt, lap, tee, and outside corner welds on .080" mild steel in flat position.

REVIEW POINTS

1. Complete butt, lap, tee, and outside corner welds in flat position.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

TIG Welding
Lesson Plan 5

Suggested instructional time
9 class periods

HORIZONTAL POSITION WELDING ON MILD STEEL

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform horizontal position butt, lap, tee, and outside corner welds on mild steel. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for horizontal position welding on mild steel. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for horizontal position butt weld, lap weld, tee weld, and outside corner welds on mild steel.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 20
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Welding in the horizontal position tends to be one of the more difficult procedures. Therefore, a great deal of practice is needed for this type of welding until it is thoroughly learned.

Presentation Outline	Activities
I. Equipment and Accessories	1. Select equipment and accessories.
II. Horizontal Position Welds	2. Set up and adjust for horizontal position welds.
III. Demonstrate Procedures	3. Perform horizontal position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete butt, lap, tee, and outside corner welds in horizontal position.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

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TIG Welding
Lesson Plan 6

Suggested instructional time
9 class periods

VERTICAL POSITION WELDING ON MILD STEEL

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform vertical position butt, lap, tee, and outside corner welds on mild steel. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for vertical position welding on mild steel. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for vertical position butt welds, lap welds, tee welds, and outside corner welds on mild steel.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 20
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Welding in the vertical position is another of the more difficult procedures. Because the joint to be welded cannot be moved to the easier flat position for welding, the vertical position procedure is used. Therefore, it is advantageous for the weldor to practice this type of weld until the procedure is thoroughly familiar.

Presentation Outline	Activities
I. Equipment and Accessories	1. Select equipment and accessories.
II. Vertical Position Welds	2. Set up and adjust for vertical position welds.
III. Demonstrate Procedures	3. Perform vertical position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete vertical position butt, lap, tee, and outside corner welds on mild steel.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

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TIG Welding
Lesson Plan 7

Suggested instructional time
9 class periods

OVERHEAD POSITION WELDING ON MILD STEEL

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform overhead position butt, lap, tee, and outside corner welds on mild steel. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for overhead position welding on mild steel. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for overhead position butt welds, lap welds, tee welds, and outside corner welds on mild steel.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 20
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Of the four major weld positions, the overhead position is the most difficult for most weldors. Therefore, care should be taken to thoroughly master the procedure.

Presentation Outline	Activities
I. Equipment and Accessories	1. Select equipment and accessories.
II. Overhead Position Welds	2. Set up and adjust for overhead position welds.
III. Demonstrate Procedures	3. Perform overhead position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete overhead position butt, lap, tee, and outside corner welds on mild steel.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

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TIG Welding
Lesson Plan 8

Suggested instructional time
9 class periods

FLAT POSITION WELDING ON STAINLESS STEEL

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform flat position butt, lap, tee, and outside corner welds on stainless steel. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for flat position welding on stainless steel. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for flat position butt welds, lap welds, tee welds, and outside corner welds on stainless steel.

REFERENCES

Modern Welding, Chapter 11
Welding Technololgy, Chapter 20
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Because welds made in the flat position tend to be stronger and more easily performed, it is usually advantageous for the weldor to try to position as much of the welding as possible in the flat position.

Presentation Outline	Activities
I. Equipment and Accessories	1. Select equipment and accessories.
II. Flat Position Welds	2. Set up and adjust for flat position welds on stainless steel.
III. Demonstrate Procedures	3. Perform flat position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete flat position butt, lap, tee, and outside corner welds on stainless steel.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

TIG Welding
Lesson Plan 9

Suggested instructional time
9 class periods

HORIZONTAL POSITION WELDING ON STAINLESS STEEL

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform horizontal position butt, lap, tee, and outside corner welds on stainless steel. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for horizontal position welding on stainless steel. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for horizontal position butt welds, lap welds, tee welds, and outside corner on stainless steel.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 20
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Welding in the horizontal position tends to be one of the more difficult procedures. Therefore, it is advantageous for the weldor to practice this type of weld until the procedure is thoroughly familiar.

Presentation Outline	Activities
I. Equipment and Accessories	1. Select equipment and accessories.
II. Horizontal Position Weld	2. Set up and adjust for horizontal position weld on stainless steel.
III. Demonstrate Procedures	3. Perform horizontal position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete horizontal position butt, lap, tee, and outside corner welds on stainless steel.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

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TIG Welding
Lesson Plan 10

Suggested instructional time
9 class periods

VERTICAL POSITION WELDING ON STAINLESS STEEL

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform vertical position butt, lap, tee, and outside corner welds on stainless steel. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for vertical position welding on stainless steel. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for vertical position butt welds, lap welds, tee welds, and outside corner welds on stainless steel.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 20
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Welding in the vertical position tends to be one of the more difficult procedures. Many times the joint to be welded cannot be moved to the easier flat position for welding so the vertical position procedure is used. Therefore, it is advantageous for the weldor to practice this type of weld until the procedure is thoroughly familiar.

Presentation Outline	Activities
I. Equipment Accessories	1. Select equipment and accessories.
II. Vertical Position Weld	2. Set up and adjust for vertical position weld on stainless steel.
III. Demonstrate Procedures	3. Perform vertical position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete vertical position butt, lap, tee, and outside corner welds on stainless steel.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

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TIG Welding
Lesson Plan 11

Suggested instructional time
9 class periods

OVERHEAD POSITION WELDING ON STAINLESS STEEL

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform overhead position butt, lap, tee, and outside corner welds on stainless steel. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for overhead position welding on stainless steel. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for overhead position butt welds, lap welds, tee welds, and outside corner welds on stainless steel.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 20
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Of the four major welding positions, the overhead position is the most difficult for weldors. Therefore, care should be taken to thoroughly master the procedure.

Presentation Outline	Activities
I. Equipment and Accessories	1. Select equipment and accessories.
II. Overhead Position Weld	2. Set up and adjust for overhead position weld on stainless steel.
III. Demonstrate Procedures	3. Perform overhead position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete overhead position butt, lap, tee, and outside corner welds on stainless steel.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

TIG Welding
Lesson Plan 12

Suggested instructional time
9 class periods

FLAT POSITION WELDING ON ALUMINUM ALLOY

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform flat position butt, lap, tee, and outside corner welds on aluminum alloy. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for flat position welding on aluminum alloy. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for flat position butt welds, lap welds, tee welds, and outside corner welds on aluminum alloy.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 19
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Because welds made in the flat position tend to be stronger and more easily performed, it is usually advantageous for the weldor to try to position as much of the welding as possible in the flat position.

Presentation Outline	Activities
I. Equipment Accessories	1. Select equipment and accessories.
II. Flat Position Weld	2. Set up and adjust for flat position welds on .080" aluminum alloy.
III. Demonstrate Procedures	3. Perform flat position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete flat position butt, lap, tee, and outside corner welds on aluminum alloy.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

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TIG Welding
Lesson Plan 13

Suggested instructional time
9 class periods

HORIZONTAL POSITION WELDING ON ALUMINUM ALLOY

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform horizontal position butt, lap, tee, and outside corner welds on aluminum alloy. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for horizontal position welding on aluminum alloy. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for horizontal position butt welds, lap welds, tee welds, and outside corner welds on aluminum alloy.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 19
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Welding in the horizontal position tends to be one of the more difficult procedures. Therefore, it is advantageous for the weldor to practice this type of weld until the procedure is thoroughly familiar.

Presentation Outline	Activities
I. Equipment Accessories	1. Select equipment and accessories.
II. Horizontal Position Weld	2. Set up and adjust for horizontal position welds on .080" aluminum alloy.
III. Demonstrate Procedures	3. Perform horizontal position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete horizontal position butt, lap, tee, and outside corner welds on aluminum alloy.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

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TIG Welding
Lesson Plan 14

Suggested instructional time
9 class periods

VERTICAL POSITION WELDING ON ALUMINUM ALLOY

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform vertical position butt, lap, tee, and outside corner welds on aluminum alloy. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for vertical position welding on aluminum alloy. The student will explain and demonstrate proper selection of control settings, filler wire and welding procedure for vertical position butt welds, lap welds, tee welds, and outside corner welds on aluminum alloy.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 19
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Welding in the vertical position is another of the more difficult procedures. Because the joint to be welded cannot be moved to the easier flat position for welding, the vertical position procedure is used. Therefore, it is advantageous for the weldor to practice this type of weld until the procedure is thoroughly familiar.

Presentation Outline	Activities
I. Equipment and Accessories II. Vertical Position Weld III. Demonstrate Procedures	1. Select equipment and accessories. 2. Set up and adjust for vertical position welds on .080" aluminum alloy. 3. Perform vertical position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete vertical position butt, lap, tee, and outside corner welds on aluminum alloy.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

TIG Welding
Lesson Plan 15

Suggested instructional time
9 class periods

OVERHEAD POSITION WELDING ON ALUMINUM ALLOY

OBJECTIVE

Given necessary equipment and instruction, the student will be able to perform overhead position butt, lap, tee, and outside corner welds on aluminum alloy. The welds must be rated acceptable by instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for overhead position welding on aluminum alloy. The student will explain and demonstrate proper selection of control settings, filler wire and welding procedure for overhead position butt welds, lap welds, tee welds, and outside corner welds on aluminum alloy.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 19
Welding: Principles and Practices, Chapter 24

INTRODUCTORY STATEMENT

Of the four major welding positions, the overhead position is the most difficult for most weldors. Therefore, care should be taken to thoroughly master the procedure.

Presentation Outline	Activities
I. Equipment and Accessories II. Overhead Positions Weld III. Demonstrate Procedures	1. Select equipment and accessories. 2. Set up and adjust for overhead position welds on .080" aluminum alloy. 3. Perform overhead position butt, lap, tee, and outside corner welds.

REVIEW POINTS

1. Complete overhead position butt, lap, tee, and outside corner welds on aluminum alloy.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds to determine soundness. (optional)

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TIG Welding (Pipe)
Lesson Plan 16

Suggested instructional time
45 class periods

GAS TUNGSTEN ARC WELDING PIPE IN THE HORIZONTAL POSITION (FIXED OR ROLLED)

OBJECTIVE

Given necessary equipment and instruction, the student will be able to TIG weld mild steel, aluminum, and stainless steel pipe in the horizontal position (fixed or rolled). The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate TIG welding on mild steel pipe, aluminum pipe, and stainless steel pipe in the horizontal position (rolled or fixed).

REFERENCES

Modern Welding, Chapter 11
Welding: Principles and Practices, Chapter 25

INTRODUCTORY STATEMENT

The TIG welding on pipe produces welds that are smooth and fully penetrated. It is a better process because the welds have maximum strength, are highly resistant to corrosion, and may be used on ferrous and non-ferrous materials.

Presentation Outline	Activities
I. Equipment and Accessories II. Set Up and Demonstrate A. Rolled B. Fixed	1. Select equipment and accessories. 2. Set up and adjust the machines. 3. Bevel edges and place three small tacks on pipe. 4. Brush and clean tacks. 5. Purge inside of pipe with argon or use flux in making a smooth bead on underside. 6. Ground a two percent thoriated tungsten electrode to a point.

NOTE: During welding, electrode should point to the center of the pipe.

ROLLED

7. Begin weld below the two o'clock position and weld upward to the twelve o'clock position.
8. Rotate the pipe clockwise so that the crater of the bead deposited is just below the two o'clock position.
9. Repeat the process.
10. Use filler passes to fill pipe joint to within 1/16" of the top surface.
11. Run a cap or cover pass to insure a smooth and undercut free weld.

FIXED

12. Start at bottom of pipe, slightly below center line, and weld toward the top and slightly beyond top center.
13. Weld the other side of the pipe the same as steps 10 and 11.

REVIEW POINTS

1. Complete the pipe weld in the horizontal position (fixed or rolled).
2. All welds must be visually inspected for quality appearance.
3. Break test all welds for soundness. (optional)

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TIG Welding
Lesson Plan 17

Suggested instructional time
30 class periods

TIG WELDING ON PIPE IN THE VERTICAL FIXED POSITION

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to TIG weld mild steel, aluminum, and stainless steel pipe in the vertical fixed position. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate TIG welding mild steel pipe, aluminum pipe, and stainless steel pipe in the vertical fixed position.

REFERENCES

Modern Welding, Chapter 11
Welding: Principles and Practices, Chapter 25

INTRODUCTORY STATEMENT

The TIG welding on pipe produces welds that are smooth and fully penetrated. It is a more desirous process because the welds have maximum strength, are highly resistant to corrosion, and may be used on ferrous and non-ferrous materials.

Presentation Outline	Activities
I. Equipment and Accessories II. Set Up and Demonstrate TIG Welding in Vertical Fixed Position	1. Select equipment and accessories. 2. Set up and adjust the machines. 3. Make the first pass in four quarters. Change positions after each quarter. Observe leading edge of weld. 4. Overlap first pass at beginning and finish.

NOTE: Filler passes and the cover pass should be made as shown in textbook.

5. Position torch.
   NOTE: Weld puddle is formed on the upper pipe bevel and kept slightly above the center line of joint.
6. Move torch in small circles insuring fusion at bottom of joint with filler rod.

REVIEW POINTS

1. Complete the pipe weld in the vertical fixed position.
2. All welds must be visually inspected for quality appearance.
3. Break test all welds for soundness. (optional)

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TIG Welding
Lesson Plan 18

Suggested instructional time
15 class periods

V-GROOVED WELD ON MILD STEEL PIPE
PIPE AXIS 45° FIXED (6-G)

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to perform V-groove welds on mild steel pipe in the 45° fixed position. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate proper selection of TIG equipment and accessories for 45° fixed position welding on mild steel pipe. The student will explain and demonstrate proper selection of control settings, filler wire, and welding procedure for V-groove welds on mild steel pipe.

REFERENCES

Gas Tungsten Arc Welding (TIG) Pipe and Tubing (EW-269 GTAWP)
Hobart School of Welding Technology

INTRODUCTORY STATEMENT

Welding in the 45° fixed position enables students to develop skills sufficient to pass a qualification test as required by industry.

Presentation Outline	Activities
I. Equipment and Accessories	1. Select equipment and accessories.
II. Weld 45° Fixed Position	2. Set up and adjust for 45° fixed position welds on schedule 40 pipe. See following drawing.
III. Demonstrate Procedures	3. Perform 45° fixed position welds on schedule 40 pipe.

REVIEW POINTS

1. All welds must be visually inspected for quality appearance.
2. Guided bend coupon test (180°) all welds to determine soundness.
3. Guided bend coupon test (180°) on both bead and root passes.

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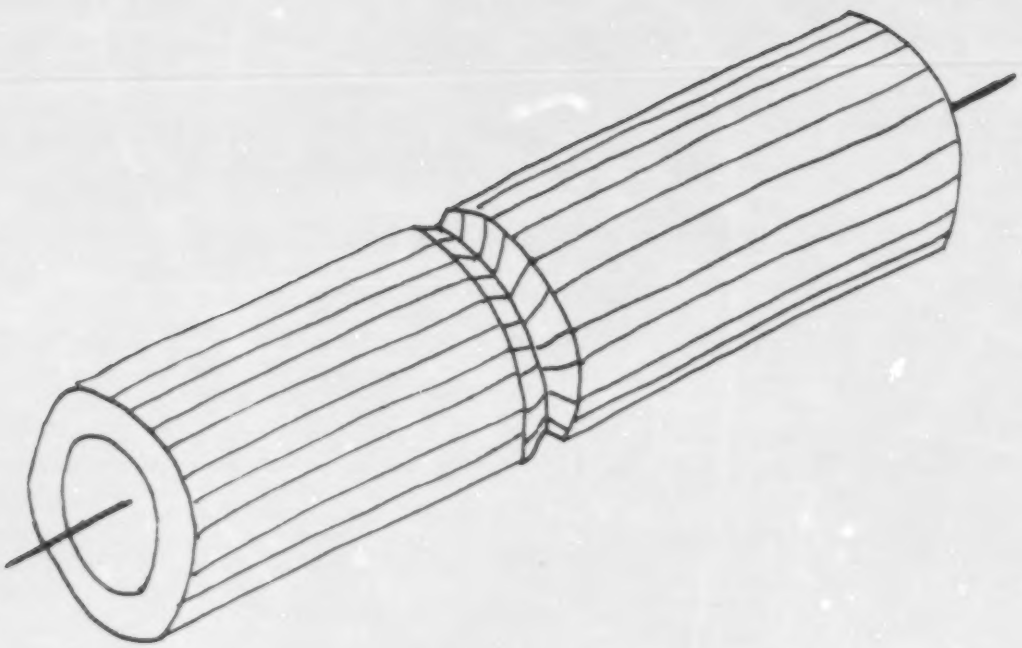
TIG WELDING

V-GROOVE WELD STEEL PIPE

FIXED POSITION (6-G)



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MIG WELDING

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MIG Welding
Lesson Plan 1

Suggested instructional time
6 class periods

SETTING UP MACHINES

OBJECTIVE

Given necessary equipment and instruction, the student will be able to set up the MIG welding station following the proper sequence and describe the safety precautions with 95% accuracy.

CRITERION - REFERENCE MEASURE

The student will explain and demonstrate the proper sequence to follow in setting up MIG equipment and the necessary safety precautions. The student will identify the major parts of the MIG welding station.

REFERENCES

Welding Technology, Chapter 22
Modern Welding, Chapter 11
Welding: Principles and Practices, Chapter 10

INTRODUCTORY STATEMENT

An accomplished MIG weldor who is experienced in setting up the welding machine knows the names of the parts of the machine and is able to use it properly.

Presentation Outline

Identify Parts

I. Welding Machine
   - A. Ground connection
   - B. Positive/negative terminals
   - C. On-off switch
   - D. 110-V AC plug
   - E. Current control
   - F. Volt/amp meters

Activities

1. Show how welding machine is started.
2. Show how to strike an arc using the MIG welder.
3. Run beads using the MIG welder.

II. Control System
   A. On-off switch
   B. Gas line connections
   C. Wire feed speed control
   D. Wire drive control
   E. Arc start switch
   F. Timer
   G. Gas source
   H. Wire feed drive motor
   I. Torch

REVIEW POINTS

1. Demonstrate how to hook up the MIG welding machine.
2. From a drawing of the MIG welding machine, identify each part.
3. Provided with a plate, strike an arc and run beads.

MIG Welding
Lesson Plan 2

Suggested instructional time
3 class periods

SELECTION OF FILLER WIRE AND CURRENT SETTING

OBJECTIVE

Given necessary equipment and instruction, the student will be able to set the machine for a given welding operation. Inspection by the instructor must be rated acceptable.

CRITERION - REFERENCE MEASURE

The student will define the spray arc method, the dip transfer method, the magnetic flux method, and the flux cored process. The student will explain the three basic types of gas metal arc welding processes.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 10

INTRODUCTORY STATEMENT

Direct current and some alternating current welding machines are used in MIG welding. There are two basic methods of transferring the metal through the arc; the spray and the dip transfer method. There are many different alloys and thicknesses of metal used along with filler metal in MIG welding.

Presentation Outline	Activities
I. Spray Arc Method II. Dip Transfer Method III. Magnetic Flux Process IV. Flux Cord Process V. Charts Determining Electrode Size, Alloy, and Feed Speed VI. Wire Selection VII. Machine Threading VIII. Gas Flow Setting IX. Wire Feed Speed Setting	1. Inspect different welds and match them with different filler metals to determine which process was used while making them.

REVIEW POINTS

1. Name the two methods of metal transfer in MIG welding.
2. What are the three basic types of gas metal arc welding processes?
3. According to the table 969.11 AWS, what filler metal is recommended for welding 5456 aluminum to 6071 aluminum? What alternate may be used?

MIG Welding
Lesson Plan 3

Suggested instructional time
3 class periods

IDENTIFYING GASES

OBJECTIVE

Given necessary materials and instruction, the student will be able to identify the correct gas for a given application with 95% accuracy.

CRITERION - REFERENCE MEASURE

The student will describe the types of gases used in MIG welding and the characteristics of argon, helium, and CO_2.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 10

INTRODUCTORY STATEMENT

The purpose of using inert gas during arc welding is to keep oxygen and other contaminates away from the high temperature molten metal. By eliminating oxidation and other impurities, welds are accomplished which had seemed impossible or impractical on certain metals. This weld with inert gas would be very difficult using other arc welding methods. Fundamentally, the MIG welding process consists of performing a weld in which the arc is surrounded by an inert gas such as helium, argon, or carbon dioxide.

Presentation Outline	Activities
Types of Gases I. Argon II. Helium III. CO_2 IV. Combination of Gases A. Argon oxygen	1. Select a proper gas for a given job of welding. 2. Prepare a paper on "Shielding Gases" in MIG welding and present it to the class for discussion.

B. Argon helium
C. Argon hydrogen
D. Carbon dioxide-argon
E. Carbon dioxide-oxygen
F. Argon-ditrogen

REVIEW POINTS

1. Describe the types of gases used in MIG welding.
2. Describe the characteristics of argon, helium, and CO_2.

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MIG Welding
Lesson Plan 4

Suggested instructional time
3 class periods

TROUBLE SHOOTING AND CORRECTIVE MEASURES

OBJECTIVE

Given necessary materials and instruction, the student will be able to detect improper welds and take corrective action with 95% accuracy.

CRITERION - REFERENCE MEASURE

The student will describe the reasons for excessive built-up, pin holes, and burnbacks in MIG welding. The student will explain insufficient cleaning action by the arc.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 10

INTRODUCTORY STATEMENT

There are many variables during the MIG welding process which can cause poor quality welds or impede the progress of the weld. This lesson addresses some of these variables and how to cope with them.

Presentation Outline	Activities
I. Excessive Build Up at Start II. Porosity and Pin Holes A. Current too high B. Improper gas coverage III. Burnbacks IV. Insufficient Cleaning Action By the Arc	1. Show examples of poor welds and tell how they were made. 2. Have the student make welds with poorly adjusted machine.

REVIEW POINTS

On an incorrectly set machine, adjust the machine to proper setting within a given period of time.

MIG Welding
Lesson Plan 5

Suggested instructional time
12 class periods

RUNNING BEADS IN THE FLAT, HORIZONTAL, VERTICAL, AND OVERHEAD POSITIONS

OBJECTIVE

Given necessary equipment and instruction, the student will be able to establish the arc and run beads in the flat, horizontal, vertical, and overhead positions. The arc and beads must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate establishing the arc and running beads in the flat, horizontal, vertical, and overhead positions.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

The equipment used in MIG welding is very expensive. It is necessary that the student understand and follow the correct procedure and safety precautions.

Presentation Outline	Activities
I. Establishing the Arc II. Running Beads in All Positions	1. Select and prepare the metal. 2. Run beads in the flat, horizontal, vertical, and overhead positions.

REVIEW POINTS

Run beads in the flat, horizontal, vertical, and overhead positions.

MIG Welding
Lesson Plan 6

Suggested instructional time
12 class periods

FLAT POSITION WELDS ON MILD STEEL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to make butt welds, lap welds, and tee welds in the flat position on mild steel plate. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt joint, the lap joint, and the tee joint in the flat position.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

A weldor must perform welds on all types of joints when welding mild steel. The procedures and techniques required to weld mild steel are demonstrated on the three joints in the flat position.

Presentation Outline	Activities
I. Procedure II. Corrective Measures	1. Set up and test equipment. 2. Select wire and prepare metal. 3. Wear protective clothing. 4. Position and tack metal. 5. Weld joint. 6. Clean and inspect. 7. Shut down and secure equipment.

REVIEW POINTS

1. Complete the flat position butt joint, lap joint, and tee joint on mild steel.
2. All welds must pass a visual inspection and/or destruction-type test.

MIG Welding
Lesson Plan 7

Suggested instructional time
12 class periods

HORIZONTAL POSITION WELDS ON MILD STEEL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to make butt welds, lap welds, and tee welds in the horizontal position on mild steel plate. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt joint, the lap joint, and the tee joint in the horizontal position.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

A welder must perform welds on all types of joints when welding mild steel. The procedures and techniques required to weld mild steel are demonstrated on the three joints in the horizontal position.

Presentation Outline	Activities
I. Procedure	1. Set up and test equipment.
II. Corrective Measure	2. Select wire and prepare metal.
	3. Wear protective clothing.
	4. Position and tack metal.
	5. Weld joint.
	6. Clean and inspect.
	7. Shut down and secure equipment.

REVIEW POINTS

1. Complete the horizontal position butt joint, lap joint, and tee joint on mild steel.
2. All welds must pass a visual inspection and/or destruction-type test.

MIG Welding
Lesson Plan 8

Suggested instructional time
12 class periods

VERTICAL POSITION WELDS ON MILD STEEL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to make butt welds, lap welds, and tee welds in the vertical position on mild steel plate. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt joint, the lap joint, and the tee joint in the vertical position.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

A weldor must perform welds on all types of joints when welding mild steel. The procedures and techniques required to weld mild steel are demonstrated on the three joints in the vertical position.

Presentation Outline	Activities
I. Procedure II. Corrective Measures	1. Set up and test equipment. 2. Select wire and prepare metal. 3. Wear protective clothing. 4. Position and tack metal. 5. Weld joint. 6. Clean and inspect. 7. Shut down and secure equipment.

REVIEW POINTS

1. Complete the vertical position butt joint, lap joint, and tee joint on mild steel.
2. All welds must pass a visual inspection and/or destruction-type test.

MIG Welding
Lesson Plan 9

Suggested instructional time
12 class periods

OVERHEAD POSITION WELDS ON MILD STEEL

OBJECTIVE

Given the necessary equipment and instruction, the student will be able to make butt welds, lap welds, and tee welds in the overhead position on mild steel plate. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt joint, the lap joint, and the tee joint in the overhead position.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

A welder must perform welds on all types of joints when welding mild steel. The procedure and techniques required to weld mild steel are demonstrated on the three joints in the overhead position.

Presentation Outline	Activities
I. Procedure II. Corrective Measures	1. Set up and test equipment. 2. Select wire and prepare metal. 3. Wear protective clothing. 4. Position and tack metal. 5. Weld joint. 6. Clean and inspect. 7. Shut down and secure equipment.

REVIEW POINTS

1. Complete the overhead position butt joint, lap joint, and tee joint on mild steel.
2. All welds must pass a visual inspection and/or destruction-type test.

MIG Welding
Lesson Plan 10

Suggested instructional time
12 class periods

FLAT POSITION WELDS ON ALUMINUM ALLOY

OBJECTIVE

Given necessary equipment and instruction, the student will be able to make butt welds, lap welds, and tee welds in the flat position on aluminum plate. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt joint, lap joint, and tee joint in the flat position.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

A welder must perform welds on all types of joints when welding aluminum. The procedures and techniques required to weld aluminum are demonstrated on the three joints in the flat position.

Presentation Outline	Activities
I. Procedure	1. Set up and test equipment.
II. Corrective Measures	2. Select wire and prepare metal.
	3. Wear protective clothing.
	4. Position and tack metal.
	5. Weld joint.
	6. Clean and inspect.
	7. Shut down and secure equipment.

REVIEW POINTS

1. Complete the flat position butt joint, lap joint, and tee joint on aluminum.
2. All welds must pass visual inspection and/or destructive-type test.

MIG Welding
Lesson Plan 11

Suggested instructional time
12 class periods

HORIZONTAL POSITION WELDS ON ALUMINUM ALLOY

OBJECTIVE

Given necessary equipment and instruction, the student will be able to make butt welds, lap welds, and tee welds in the horizontal position on aluminum plate. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt joint, lap joint, and tee joint in the horizontal position.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

A weldor must perform welds on all types of joints when welding aluminum. The procedures and techniques required to weld aluminum are demonstrated on the three joints in the horizontal position.

Presentation Outline	Activities
I. Procedure II. Corrective Measures	1. Set up and test equipment. 2. Select wire and prepare metal. 3. Wear protective clothing. 4. Position and tack metal. 5. Weld joint. 6. Clean and inspect. 7. Shut down and secure equipment.

REVIEW POINTS

1. Complete the horizontal position butt joint, lap joint, and tee joint on aluminum.
2. All welds must pass visual inspection and/or destructive-type test.

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MIG Welding
Lesson Plan 12

Suggested instructional time
12 class periods

VERTICAL POSITION WELDS ON ALUMINUM ALLOY

OBJECTIVE

Given necessary equipment and instruction, the student will be able to make butt welds, lap welds, and tee welds in the vertical position on aluminum plate. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt joint, lap joint, and tee joint in the vertical position.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

A weldor must perform welds on all types of joints when welding aluminum. The procedures and techniques required to weld aluminum are demonstrated on the three joints in the vertical position.

Presentation Outline	Activities
I. Procedure	1. Set up and test equipment.
II. Corrective Measures	2. Select wire and prepare metal.
	3. Wear protective clothing.
	4. Position and tack metal.
	5. Weld joint.
	6. Clean and inspect.
	7. Shut down and secure equipment.

REVIEW POINTS

1. Complete the vertical position butt joint, lap joint, and tee joint on aluminum.
2. All welds must pass visual inspection and/or destructive-type test.

MIG Welding
Lesson Plan 13

Suggested instructional time
15 class periods

OVERHEAD POSITION WELDS ON ALUMINUM ALLOY

OBJECTIVE

Given necessary equipment and instruction, the student will be able to make butt welds, lap welds, and tee welds in the overhead position on aluminum plate. The welds must be rated acceptable by the instructor.

CRITERION - REFERENCE MEASURE

The student will explain the procedure and demonstrate the butt joint, lap joint, and tee joint in the overhead position.

REFERENCES

Modern Welding, Chapter 11
Welding Technology, Chapter 22
Welding: Principles and Practices, Chapter 26

INTRODUCTORY STATEMENT

A weldor must perform welds on all types of joints when welding aluminum. The procedures and techniques required to weld aluminum are demonstrated on the three joints in the overhead position.

Presentation Outline	Activities
I. Procedure II. Corrective Measures	1. Set up and test equipment. 2. Select wire and prepare metal. 3. Wear protective clothing. 4. Position and tack metal. 5. Weld joint. 6. Clean and inspect. 7. Shut down and secure equipment.

REVIEW POINTS

1. Complete the overhead position butt joint, lap joint, and tee joint on aluminum.
2. All welds must pass visual inspection and/or destructive-type test.

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EQUIPMENT LIST

WELDING EQUIPMENT LIST

REVISION DATE: June 8, 1981

In establishing a new program, school districts are funded for only basic instructional equipment as indicated on this list. When a particular piece of equipment is not indicated on this list but is utilized by local industry and asked for by a school district, this equipment can be requested by the appropriate school administrator.

The committee of instructors who developed this list has indicated particular manufacturers or sources of equipment; however, any equipment with the same qualifications may be substituted by the local school/center.

QUANTITY	ITEM & SIZE	MANUFACTURER OR SOURCE	MODEL
1	12" Adj. Wrench	Williams	AP 12
2	Air-cooled torches	Weldcraft	WP260-25
1	250 AMP AC-DC Tig welder, water w/Circ.	PWS Co.	1341-0118
1	250 AMP AC-DC Tig welder, gas	Miller - PW	1341-0158
12	250 AMP AC-DC welders,	Lincoln PW	T.M.
3	250 AMP AC-DC welders	Hobart	
3	250 AMP AC-DC welders	Airco	MSM Bumblebee
1	225/200 AMP gas driven welder	Miller	1350-0036
1	250 AMP Mig power supply	Airco	2:5DTR-224-A
1	140 lb. anvil	Brodhead-Garrett	140
500 ft.	#1/0 AWG stranded cable - 30 AWG	Belden	Neopreme
500 ft.	#1 AWG stranded cable - 30 AWG	Belden	Neopreme
4	Ball pein hammers, 16 oz. P-P	Plumb	10-8802
4	Ball pein hammers, 24 oz. Paxton	Plumb	M-754B
1	8" bench vise (swivel base)	Wilton	500S P.P
2	4" bench vise (swivel base)	Wilton	400S
2	Boxes 1/8" 2% tungsten	Airco	2309-0644
2	Boxes 1/16" 2% tungsten	Airco	2309-0642
2	Boxes 3/32" 2% tungsten	Airco	2309-0643
6 pr.	Brazing Goggles	Jackson	Unigoggles 11 #5
14	1/0 cable lugs	Airco	1323-0201
24	Chipping hammers	Airco	Mod L
100	Clear plastic lens 2 x 4¼"	Airco	1307-0108
3	3/4" cold chisels, P-P 7"	Hargrave	18-8370
1	Combination square set (12")	Starrett	

QUANTITY	ITEM & SIZE	MANUFACTURER OR SOURCE	MODEL
1	Cut-off saw 5 h.p.	Brilliant	BA05037
6	12" diameter round files	Nicholson	50259-10"
6	8" dividers	Starrett	277
5	12" double cut files h/round		50140
1	8" double end buffer with brushes	P.P.	330-B
1	4" drill press vise		GH563-0131
2	Emery wheel dressers	Hunter	1
12	Electrode holders	Jackson	JH3
2	50' extension cords 12/3		0450
6	Face shields 12"	PWS Co.	8040
50	Filter lens #10 (2" x 4½")	Airco	1307-0540
50	Filter lens #5 (2" x 4½)	Airco	1307-0538
1 Gr.	Flat soap stone	Airco	
5	12" fine files	Stanley	50125
1	15" floor drill press		GH.774-0068
6	Flow meters	Harris	1-AP70F0580
1	Framing Square	Stanley	R100B
24	7 x 1/4" x 5/8" grinding wheels	Bay State	1/4 x 7 x 5/8
12	Ground clamps	Jackson	CC3
2	Hand hacksaws	PW Co.	10-6000 P.P.
6	Headgear	Jackson	131
25 prs.	Leather gloves	PW Co.	PW09555
1	24" level	Stanley	233L
20	teaching kit & tools	Brodhead-Garrett	491672
1	Midget feeder	PW Co.	000-394
1	Mobilematic feeder w/10" hose and cables	Miller	552-E
2	Packs wrenches (5/16" thru 1½")	Williams	WS 1172SR
24 prs.	Safety glasses	PW Co.	#3465
1	Pedestal grinder W/2" - 60 grit and 2" - 36 grit	Beldoy	1215-w 12" (G.H.)
3	6" Phillips screw drivers	Stanley	2753
1	Pipe cutting and beveling machine w/torch tip gauges	H&M	H-M
6	Pliers	Williams	PL 57
2	Pliers, visegrip		9-R
1	10 lb. sledge hammer		109060 P.P.
5	10" power lock tapes	Lufkin	
1	Radiograph with tip-torch-lubricant 12" track and gauges w/torch		507-700-1C

QUANTITY	ITEM & SIZE	MANUFACTURER OR SOURCE	MODEL
20	Replacement flints (tripple)	PW Co.	
1	Teacher's metric teaching kit and tools	Brodhead-Garrett	4918
5	Tip cleaners	PW Co.	
10	Triple flint torch lighters	PW Co.	
2	3/8" variable drills	B & D	1170
2 sets	Allen wrenches	Allen	KW-7
2 sets	Drill bits 1/64 thru 1/2	Chicago-Latrobe	HF 27
1 set	Drills 9/16" thru 1" turn shanks	Chicago-Latrobe	431-1203
1 set	Sockets and ratchet ½"	Williams	WSS4
1 set	Sockets and ratchet 3/8"	Williams	WS B4
2	48 oz. shop hammers	Plumb	10.9052 P.P.
4	Side grinders 7"	MACITA PW Co.	9607B
10	Slip joint pliers	Utica	7-8"
1	Spot Welder	Miller	MSW-417
6	Stainless steel brushes	Anderson-PW Co.	14155
1	50' steel tape	Lufkin	141
24	Steel wire brushes 12"		
2	6" straight screw drivers	Stanley	1007
1	12" straight screw drivers	Williams	DRG-32
1	Water cooled torch	Weldcraft-PW Co.	WP18-25
5	4" Weldor C-clamps	Wilton PW Co.	43
5	6" Weldore C-clamps	Wilton PW Co.	43
5	8" Weldore C-clamps	Wilton PW Co.	43
24	Welding helmets, big J with wide small lents	Jackson - PW Co.	43
6	Welding and cutting outfits	Harris PW Co.	8530
2	Tri-Square 8" blade	Stanley	